AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

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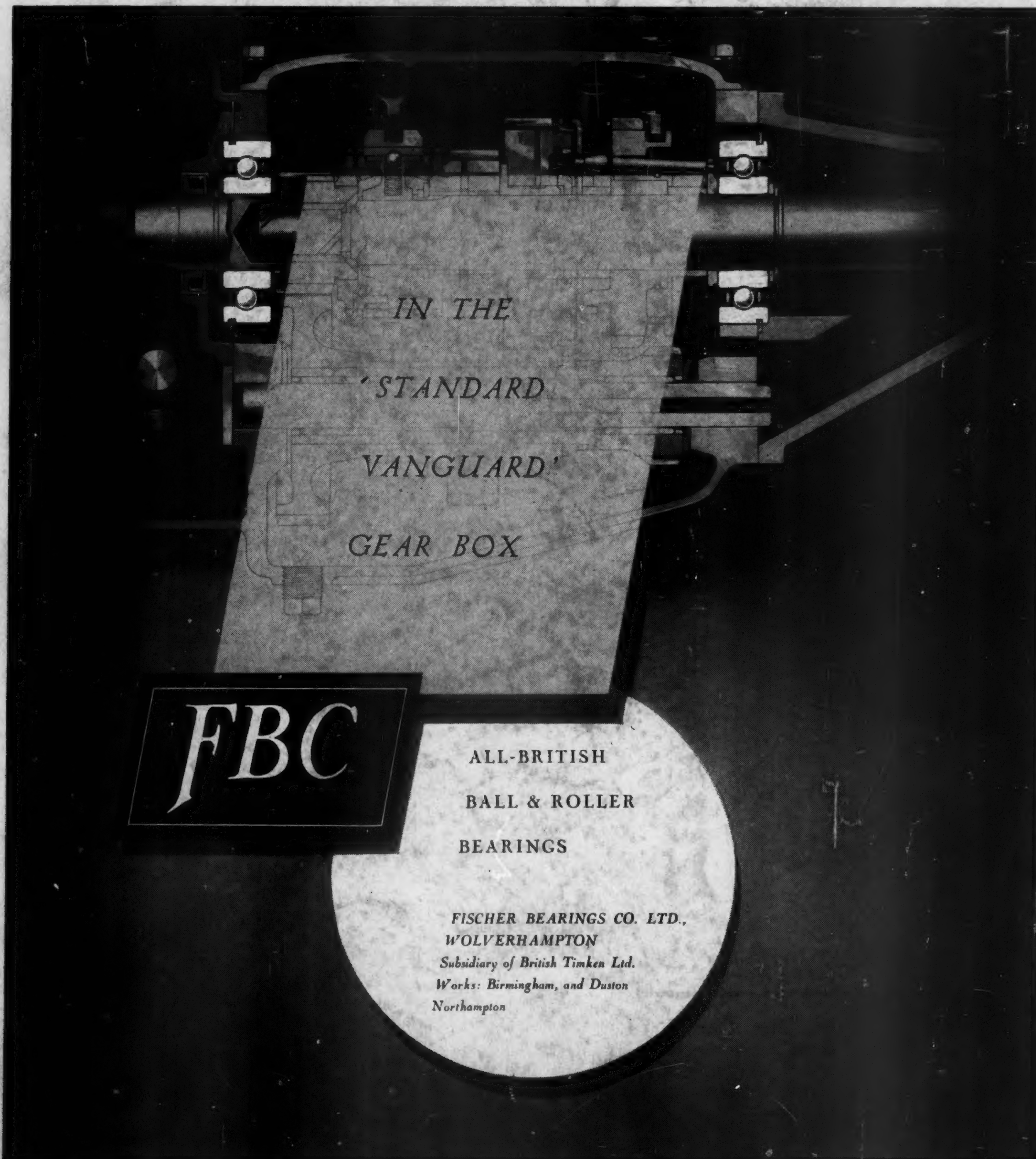

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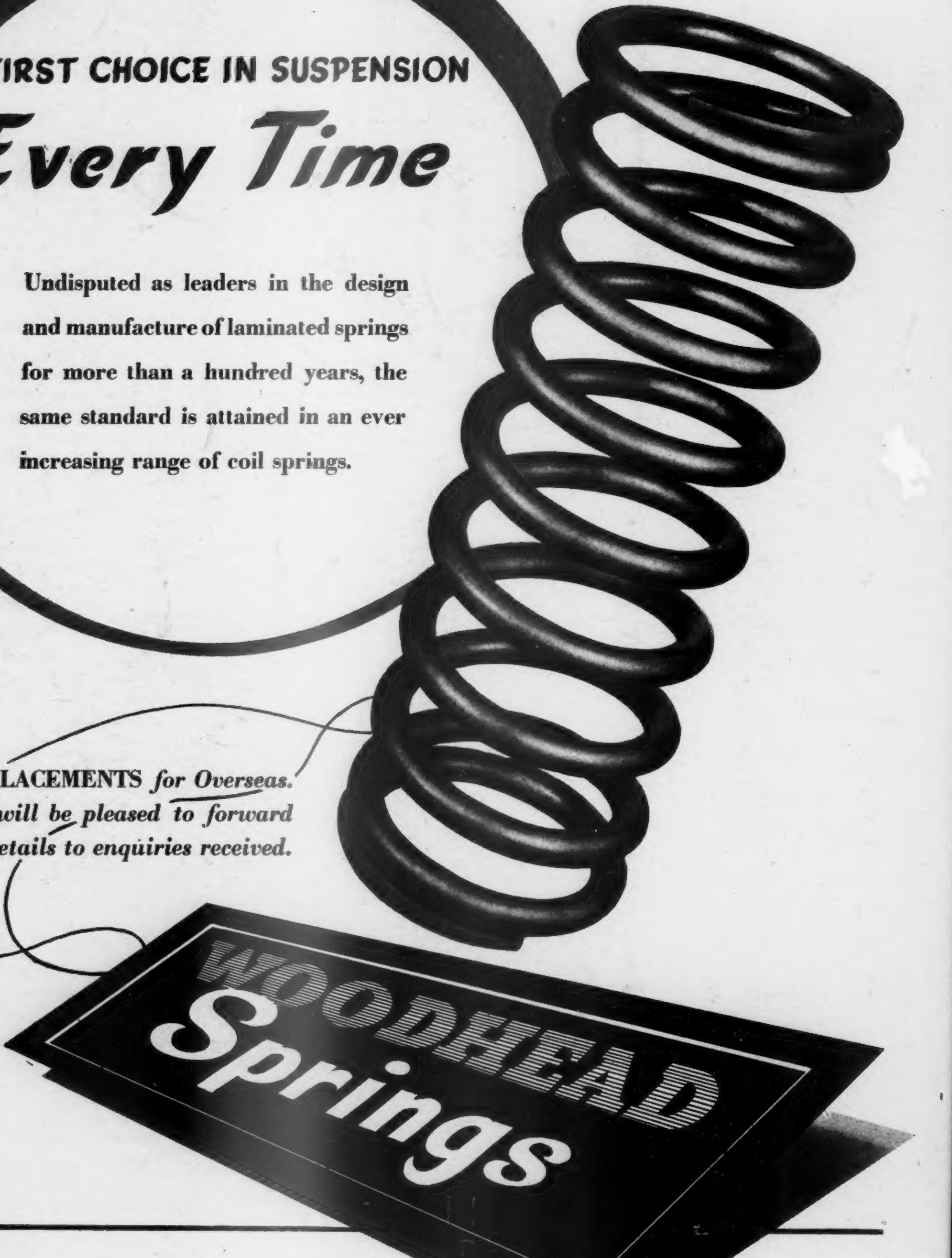

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NUMBER 535 SHOULD READ 536

AUTOMOBILE ENGINEER

Design, Materials, Production Methods, and Works Equipment

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Refinement

IT is unfortunate that in present conditions there is little opportunity for the mass of British automobile engineers to gain extended experience of the latest American cars. There is still far too little realisation that in performance and passenger amenity, the present day standards are very high indeed. Several of the latest examples have been briefly sampled by the *Automobile Engineer*. The principal purpose of these trials was to acquire first-hand experience of the various types of automatic transmission. The outstanding and lasting impressions, made by all of them however, were not related to the merits or otherwise of these transmissions, but to their overall excellence as road vehicles. The riding, handling and, above all, the silence and general refinement of all these cars puts them at once into a class apart.

Comment on the automatic transmissions is deferred, and a detailed technical review of current American designs is in preparation. These systems have however, undoubtedly influenced the design of other components, notably the engine. Outstanding refinement in the power unit and its installation is essential owing to the fact that the engine revolutions rise sharply until the road speed has, so to speak, "caught up "with the engine. Designers have therefore concentrated their attention upon silencing the engine and rendering it almost completely remote from the occupants of the car. These efforts have been successful to an altogether remarkable degree.

British Needs

The American car is not completely suited to British road conditions, if only by reason of sheer bulk and steering ratio. This, in general, is too low for complete confidence in the dire emergencies so common on our inadequate roads. It was nevertheless felt by more than one experienced driver that in any of these cars the prospect of a long journey at high speed offered more attraction than usual. Although much of this feeling is attributable to the basic factor of good power/weight ratio, the outstanding silence and smoothness undoubtedly played a large part. By comparison, most British cars fall short of this standard, even when vehicles of similar power/weight ratio are under consideration.

Power/weight ratio is one of the primary reasons for the superiority of the American over the average British car. This advantage should however, be quite appreciably offset by the unusual engine operating conditions, resulting from the use of automatic transmissions. It should be emphasized nevertheless that although the American car bears this handicap, it is in general a superior motor car.

Higher Standards

As a direct result of our tests, the conviction grows that much remains to be done on many British cars in the matter of isolating the mechanical units from the passengers. This greater refinement of the American product cannot be dismissed entirely on the grounds of either power/weight ratio, or of the multiplicity of cylinders general on the American car. One British saloon having a large four-cylinder engine has, in the course of 20,000 miles in the service of the *Automobile Engineer*, left quite an exceptional impression of refinement, at all but the lowest speeds. It approximates very closely indeed to the characteristics of the average American car, and also to the price. What may be justifiably criticised is the fact that the performance of this particular car appears to be exceptional. It is by no means an expensive vehicle, and there seems no adequate reason why comparable cars of other makes should not at least equal its performance in this matter of refinement.

There are few normal production British cars with which even a mildly critical passenger could not find fault on the grounds of body drumming, "power roar" from the induction system, and transmitted vibration. Not all cars have these three typical faults in combination, but most have one or two of them. It is these variations that interest the critical observer and irritate the discriminating driver or passenger. Why, for example, should engine mounting technique differ so widely from make to make? Taking the four cylinder engine as the most obvious case, it appears inexplicable why some examples are so very far below the best that at once spring to mind. With so much of component manufacture in the hands of specialists, the same technique must be available to all car manufacturers. Why do they not make use of the available information?

Two contributory causes to this generally unsatisfactory state of the British car may be suggested, and one of these

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is the repressed British motorist. British motoring minds have been conditioned by the deplorable discouragement and persecution of motoring in this country. The typical British motorist is still too ready to excuse the shortcomings of his cherished mechanism, rather than to demand that the standard of his transportation should equal that of other countries. Further, absence of new vehicles has made the public hardened to second rate motoring on out of date cars. The second may be the size of the British industry. It is a commonplace to hear the opinion expressed that the motor industry is highly competitive. So it is, but is it competitive enough ?

Industrial Magnitude

May not the quality of the American car spring from the fact that the size of the American industry is ten times that of the British industry ? Since the penalties for failure of a new model are so heavy, prototype development is a most serious matter and is conducted as such, and on the appropriate scale. Also, at a cost of say a dollar a car, fabulous sums become available for research and development work. It is doubtful whether British prototype work can ever be carried out on anything approaching a proportionate scale. Possibly then, many of the shortcomings of the British car spring from the very smallness of the industry. They may be present, in fact, because the penalties for failure are merely serious, not disastrous.

Against this view however, is the fact that some firms make fewer mistakes than others, and these firms are not always those that have had the greatest financial resources at their disposal. The answer is presumably as ever, ability and competence. Outstanding technical success demands at least some measure of all the higher faculties, as well as purely technical qualifications. Foresight, imagination, a genius for good guessing, courage, tenacity, all in fact that goes to a first class mind. Teamwork too, and the human qualities do not come amiss. Whatever be the ingredients, the British Industry will need them all in full measure in the years to come.

Refinement unfortunately is not a quality amenable to scientific measurement within narrow limits. To quite a large extent it is subjective so that different people may not classify different cars in the same order. Here, perhaps, personal sensitivities are developed in varying degree and accordingly respond to the same stimuli in different ways. The differences however, are rather matters of degree and in general British cars display much greater diversity than can be accounted for by differencies of this magnitude. In short, there are many examples that all would agree are unsatisfactory.

It is sometimes suggested that American cars display such a similarity of behaviour among themselves that all character is lost to individual makes. While this may be true to some extent, it is more likely to spring from the uniformity of size and performance of the vehicles, rather than from the very complete suppression of noise and transmitted vibration. In any event, there is nothing wrong with uniformity, *per se*, provided it is uniformity of high standard. Further, the nearer the approach to perfection, the more uniform any product must become. "Character", which is perhaps indefinable, is undoubtedly a valuable feature of the British car, even in a market primarily concerned with transportation. That it is not inseparable from roughness and noise has been amply demonstrated for many years on more than one make of car. Possibly it may be more difficult to retain in the quantity produced car in which many of the undesirable qualities have been suppressed, but there are doubtless wide enough differences in the basic designs of British cars to ensure that character is still preserved.

Arising out of the foregoing notes, there is a further point that certainly has considerable bearing on the matter of technical success. This is the closeness or intimacy of the co-operation between the purely scientific staff and those engaged upon severely practical matters. The major part of the activities in the drawing office are centred upon those small yet highly important matters associated with the day to day evolution of satisfactory detail. Each item however small must be developed or evolved to the requisite stage. All must be fully reliable, of minimum weight and cost, while many relatively minor items must embody other qualities as well, such as special finish, super accuracy at some point or dimension and so forth.

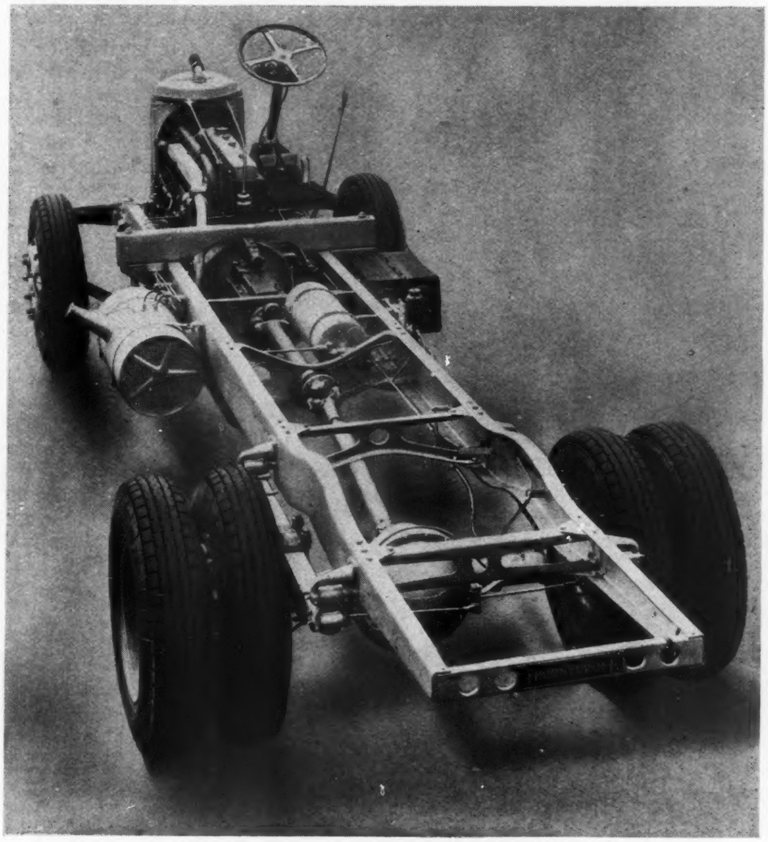
In the majority of design problems therefore, science must genuinely have a place. It is not always however, fully applied. There is particular likelihood of this omission if there is no adequately qualified advice immediately available and within the office organization. In practice it is by no means always thus available. As a result it is not employed as frequently or as fully as it should be. Some of the best automobile engineering as such, emanates from a relatively small organization where this ideal combination is fully exploited. Much of the outstanding success in this particular case is no doubt directly attributable to this way of working.

Every project or layout should be subjected to this intense scientific scrutiny and investigation. If this were done in every case many of the errors and shortcomings which are still current would not exist. Much that can be criticised in many production models could have been picked up at the design stage. Other faults in prototypes which necessitate relatively costly correction would not reach even that stage, but would also have been detected in the drawing office. Again, where this close scrutiny is practiced it will be found that even satisfactory components can be carried a stage further in the matters of simplicity, refinement, cost, or all three. In short, a full use of the scientific method pays dividends every time.

CONTENTS OF THIS ISSUE

THE THORNYCROFT TRIDENT

A Newcomer in the Medium-heavy Duty Class



The Thornycroft 'Trident' chassis.

DESIGNED to carry a payload of some eight tons, to give good performance, yet to provide effective economy in operation, the Thornycroft "Trident," fitted with the Company's latest 5.51-litre six-cylinder oil engine, should meet a definite need in the world of transport. As is to be expected from an old-established organization the designers prefer to offer solid achievement rather than spectacular novelty. The "Trident" forms one of a rationalized range of vehicles in which as many components as possible serve a number of different capacity chassis.

The "Trident" range embodies six basic types. A right-hand forward control 13ft 6in wheelbase chassis, also one of 10ft wheelbase for tippers, either of which can alternatively be fitted with a four-forward speed gearbox and a lower ratio final drive; an 8ft 6in wheelbase tractor for use with semi-trailers, and a 13ft 6in wheelbase, right or left-hand normal control chassis, essentially intended for export sales. These can also be offered with a four-speed gearbox. The 10ft wheelbase, normal control, right or left-hand drive tipper and tractor chassis are also available.

SPECIFICATION

ENGINE. Six cylinder, 5.51 litre, direct injection oil. Bore and stroke 3.875in x 4.75in. Maximum b.h.p. 78 at 1,900 r.p.m. Maximum b.m.e.p. and torque 105lb per sq. in. and 232lb. ft. at 1,300 r.p.m. Compression ratio 16.1 to 1. Overhead valves operated by push rods. Seven main bearings.

CLUTCH. Borg and Beck 14in: diameter single plate.

GEARBOX. Five forward speeds and reverse. Dog engagement on top, fourth and third. Ratios: first 8.22 : 1; second 4.875 : 1; third 2.8 : 1; fourth 1·7 : 1; top, direct: reverse 6.16 : 1.

REAR AXLE. Fully floating, hypoid bevel with straddle mounted pinion. Ratio: 5.857 : 1.

SUSPENSION. 3in wide, semi-elliptic laminated springs.

STEERING. Cam and double roller. Spring-spoked steering wheel, column adjustable for height.

BRAKES. Girling, hydraulically operated, with vacuum servo assistance.

DIMENSIONS. Wheelbase 13ft 6in.. Track-front, 5ft 8.875in., rear, 5ft 7in.

The following description relates to the long wheelbase, forward control model known as Type RG/CR6 with which when fitted as standard with 9·00—20/36 × 8in tyres, a gross laden weight of 12 tons is permissible on good roads. This is made up as follows:—

	Tons	cwt.	qrs.
Unladen chassis weight in licensing order	2	19	1
20 gal. fuel, water, tools, spare wheel and tyre		4	2
Allowance for cab..		3	3
Body and pay load	8	12	2
Gross laden weight	12	0	0

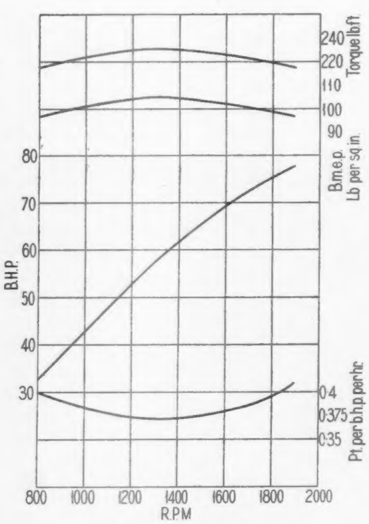
These figures are based on U.K.

tyre ratings. In places where U.S. Tyre and Rim Association ratings apply the gross permissible laden weight is reduced to 10 tons, 7 cwt. A commendable feature of these chassis is the thought that has evidently been devoted to the comfort of the men who will drive them.

Engine

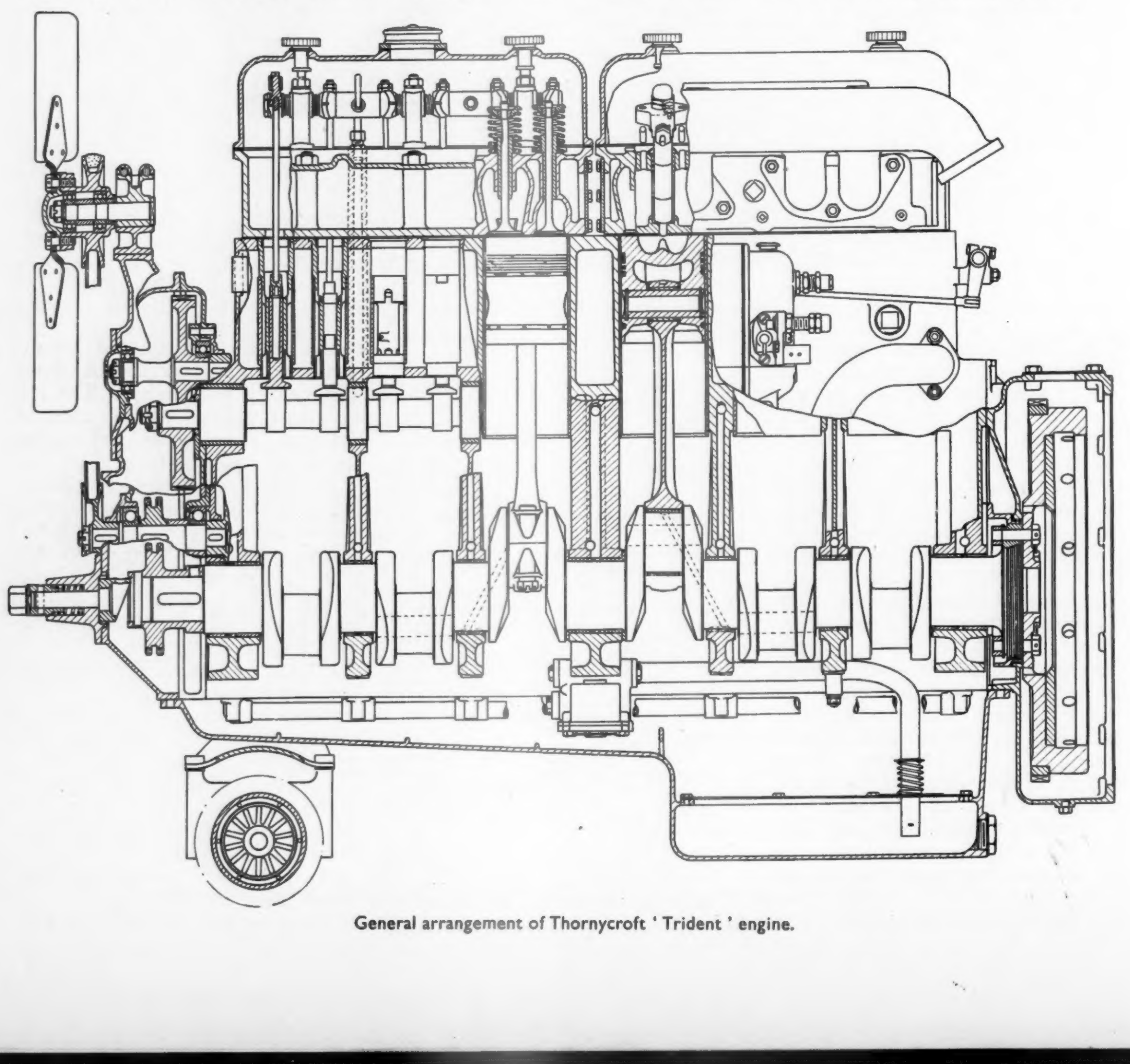
Known as type CR6, this new engine has six cylinders of 3·875in bore and 4·75in stroke, giving a swept volume of 5·51 litres. Developing a maximum of 78 b.h.p. at 1,900 r.p.m., it yields 43 b.h.p. at 1,000 r.p.m. Compression ratio is 16·1 to 1 and maximum torque is 232 lb ft and maximum b.m.e.p. is 105 lb/sq in, both at 1,300 r.p.m.

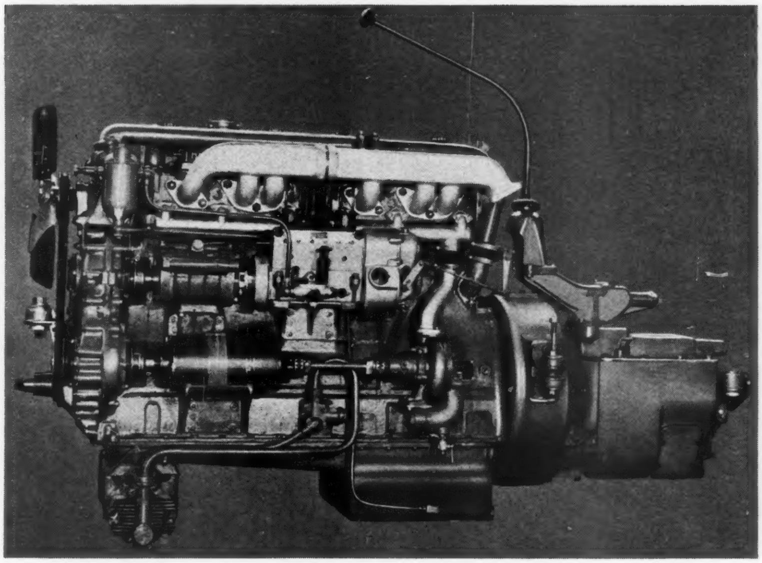
Of comparatively conventional construction, the engine has all auxiliaries other than the starter motor mounted on the near-side. The cylinder block and crankcase are cast in one from close-grained cylinder iron, the walls being as flat and straight as possible with generous internal bracing for rigidity. The casting extends 4·5in below the centre line of the crankshaft, and adequate provision is made for the coolant. There are water spaces between each bore, the centre one being very large. Removable "dry" cylinder liners are fitted to interference limits. The seven main bearings are well supported from the crankcase walls by ribs, and the timing case cover is an iron casting bolted in position.



Performance curves.

The crankshaft is stamped from nitriding steel and is fully balanced after machining. The crankpins are drilled and the lubricant is carried through the drillings via copper pipes peened in position. The main bearings are 3·1255in diameter, the front and rear being 2·25in long, and the centre 2·75in long, while the four narrow intermediate are 1·25in. This gives a total projected bearing area of 114·725 sq in. With the exception of the centre main bearing, which is flanged at either side to take the thrust, all the bearings are flangeless. The nominal running clearance for the main bearings is 0·0003in. Thin shell, pre-finished, lead bronze bearings, with surfaces lead-tin plated, are used for all mains and big-ends. The caps to the front, centre and rear main bearings are secured by four bolts, the remainder by two. Oil retention at the back of the crankshaft is by grooves in the outer edge of the flange to which the flywheel is bolted.


General arrangement of Thornycroft 'Trident' engine.



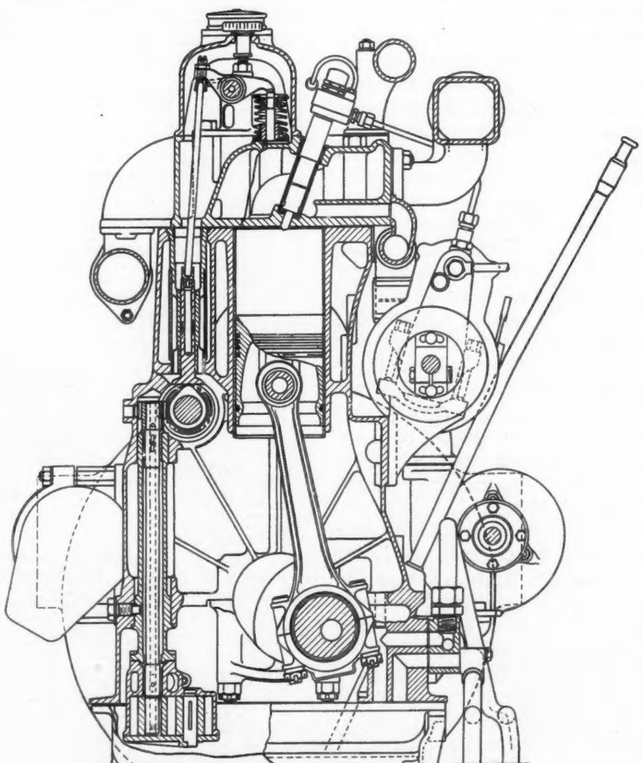
Near-side view of engine and gearbox.

An unusual feature is that the camshaft, which is mounted fairly high on the off-side of the engine, runs in 2·375in diameter aluminium bushes. The second and fifth camshaft journals are slotted through about one third of their diameter in order to permit an intermittent oil feed through pipes to the rocker shaft and the tappets.

Stamped from chrome steel, the H-section connecting rods are 10·75in long between centres. Each bearing cap is secured by two 0·437in diameter waisted bolts, which have full diameter bosses at their centres in order to locate rod and cap accurately. The big-end bearings are 2·75in diameter and 1·5in wide, having a projected bearing area of 77·8 sq in. The small end bearings are of phosphor bronze and the gudgeon pins are 1·25in diameter.

The B.H.B. aluminium alloy pistons have a toroidal cavity in the heads. They are 4·86in long and carry three compression and one scraper ring above the gudgeon pin. Provision is made for fitting a scraper ring in the skirt at first overhaul.

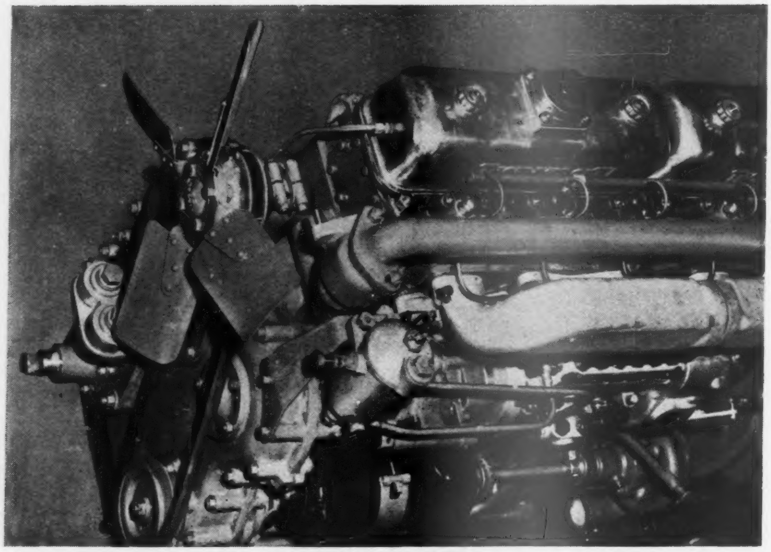
There are two cylinder heads, each covering three bores, but they are not interchangeable. Cast in chromium iron, they are fitted with thin copper-asbestos gaskets. The two overhead valves per cylinder are mounted vertically slightly off-set from the centre line of the bores. The masked inlet valves which are 1·65in diameter are of nickel steel and the 1·5in diameter exhausts are of silchrome. The air inlet manifolding is on the off-side of the engine, air being drawn through an oil bath cleaner and silencer which is normally mounted in the driver's cab but draws air from outside the cab, thus eliminating induction noise. The exhaust manifold, cast in two portions, is fitted to the near-side of the heads.



Engine cross section.

Valve actuation is through 0·625in diameter tappets made from medium carbon steel with a stellite face. They work in guides carried in the cylinder block, to the off-side, thence through push rods and rockers. The timing gear consists of an arrangement of chain and gears. A duplex chain encircles the crankshaft, the automatic tensioner sprocket, the idler sprocket and the dynamo/water pump drive sprocket. An idler gear, behind the idler chain sprocket, engages with two gears, the one on the camshaft and the other on the drive shaft for the exhauster and fuel injection pump.

The cast elektron base chamber is a cover only, for about half its length, the remaining portion forming the sump. The casting is so made that it can be fitted with the sump at the front of the engine for use on normal control vehicles, or with the sump at the rear for forward control chassis. An oil cooler and cleaner is fitted



View showing cooling system layout.

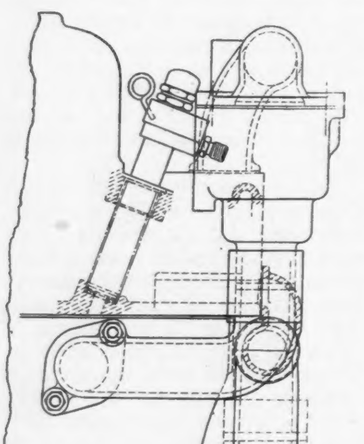
separately in front of the sump in a transverse position.

Lubrication is fully forced, the oil being drawn from the sump by a gear-type pump located near the centre of the engine, and driven by a gear formed at the centre of the camshaft. From the pump, oil is forced to each main bearing by means of a gallery pipe, also to the camshaft, the oil in circulation having first passed through the cooler. The timing gears and chain are lubricated by overflow and splash from the camshaft thrust plate and gear, the idler gear and the chain tensioner sprocket.

The capacity of the engine lubrication system is 2·75 gallons, plus 1 gallon in the oil cooler. Maximum oil pressure is 30/40 lb/sq in with 10 lb/sq in idling.

Engine cooling is on unusual lines, there being no direct flow of water between block and head by the orthodox cored holes. There are two small balance holes. The pump, of true centrifugal type, is mounted on the near-side of the engine towards the back and is driven through the dynamo by a shaft. Incidentally it may be noted that in order to keep the impeller in its proper position, the carbon gland ring is arranged to move towards the impeller as wear takes place, instead of the impeller towards the gland, as is common.

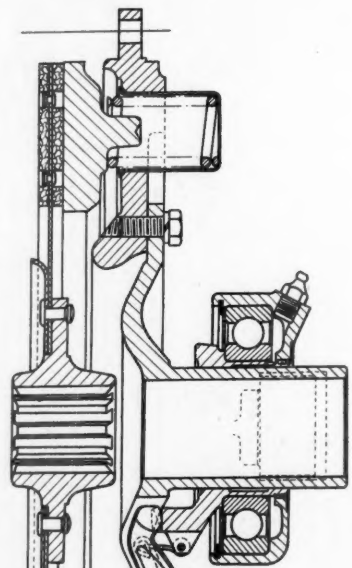
Water from the pump is delivered to a horizontal gallery pipe positioned along the lower near-side of the cylinder heads. It is then directed on to the injector nozzle shrouds, after which it flows through the waterways of the heads. From the heads it passes into another gallery pipe which leads to a thermostat. This also receives the outlet water from the cylinder block. According to the temperature of the cooling water in the cylinder block, so the water from the head is allowed to pass to the header tank of the radiator or, should the block temperature be too low, direct to the block. The aim is, while maintaining the cylinder block coolant at the right working temperature, to direct the principal cooling effect to the cylinder heads.



Water circulation passages between block and head.

The engine mountings have been designed to maintain the whole power unit in equilibrium on its torsional axis. To this end, the unit is mounted as nearly as is possible on two points. There is a bracket holding a twin rubber mounting bolted to the front of the timing case, its centres being 6·5in above the centreline of the crankshaft. Bolted to the rear face of the gearbox is the second mounting. Again there are two rubber-bushed fixings, arranged as closely together as possible. Torque reaction is absorbed by means of a double, preloaded rubber-bushed bracket on either side of the flywheel housing. It is stayed to the chassis on either side on a transverse line which passes through the centre of gravity of the unit. All the rubber bushes are preloaded so that no settlement of the power unit can occur, with resulting change in the centres of oscillation. The system gives very smooth, vibrationless running.

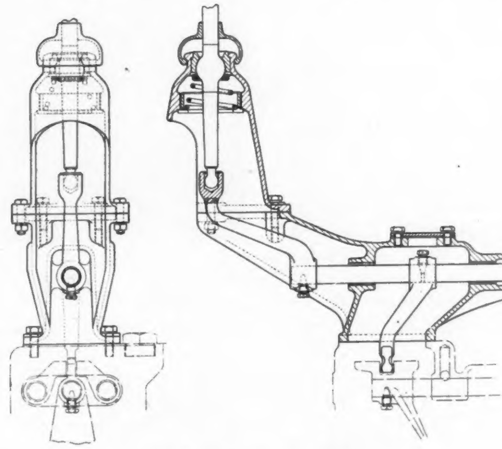
A four-bladed built-up fan is carried by two ball bearings on a spindle mounted in a bracket high up on the front of the engine. It is driven



Layout of single plate clutch.

by a belt from a pulley at the front of the dynamo and water pump drive.

C.A.V. injection equipment is fitted. The injection pump and mechanical governor mounted high up on the near-side of the engine, are driven from the timing gear train in tandem with an exhauster. The fuel feed pump is carried on the injector pump and is driven by it. A priming device is fitted. Fuel is taken from the tank through a Zenith filter. The injection pump is timed so that spill cut-off occurs at 32 deg. before T.D.C. The governor is set to give an average idling speed of 400 r.p.m. and a maximum speed, under load, of 1950 r.p.m. Runaway speed, light, is 2100 r.p.m.



Layout of selector mechanism.

Clutch

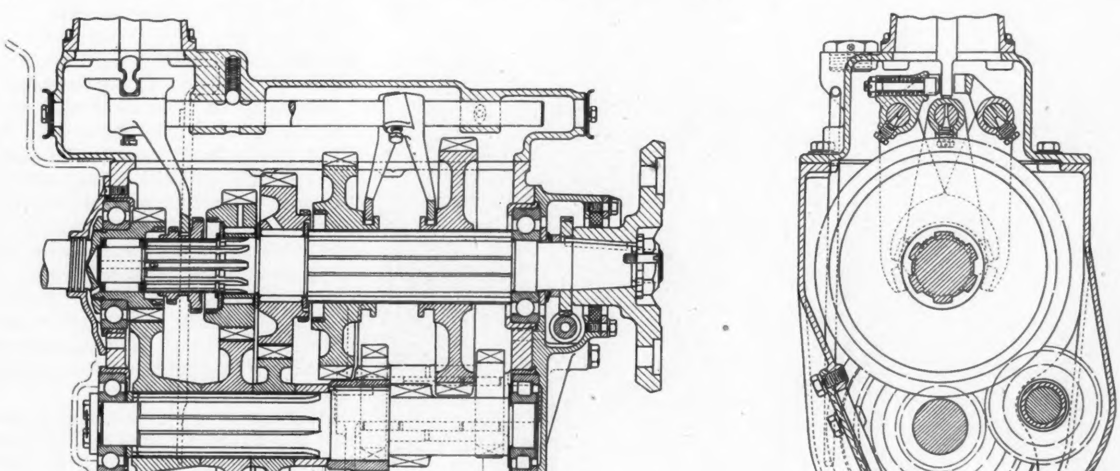
A Borg and Beck dry, single-plate type 14R4 clutch is employed. It has an effective diameter of 14in and 1in free travel at the pedal. It has fifteen springs, and the three release levers are pivoted on needle roller bearings. Operation is through a throw-out fork fitted with a heavy ball bearing, lubrication of which is effected through a flexible pipe. Wear of the friction surfaces is taken up by the simple reversal of the thrust pads.

Gearbox

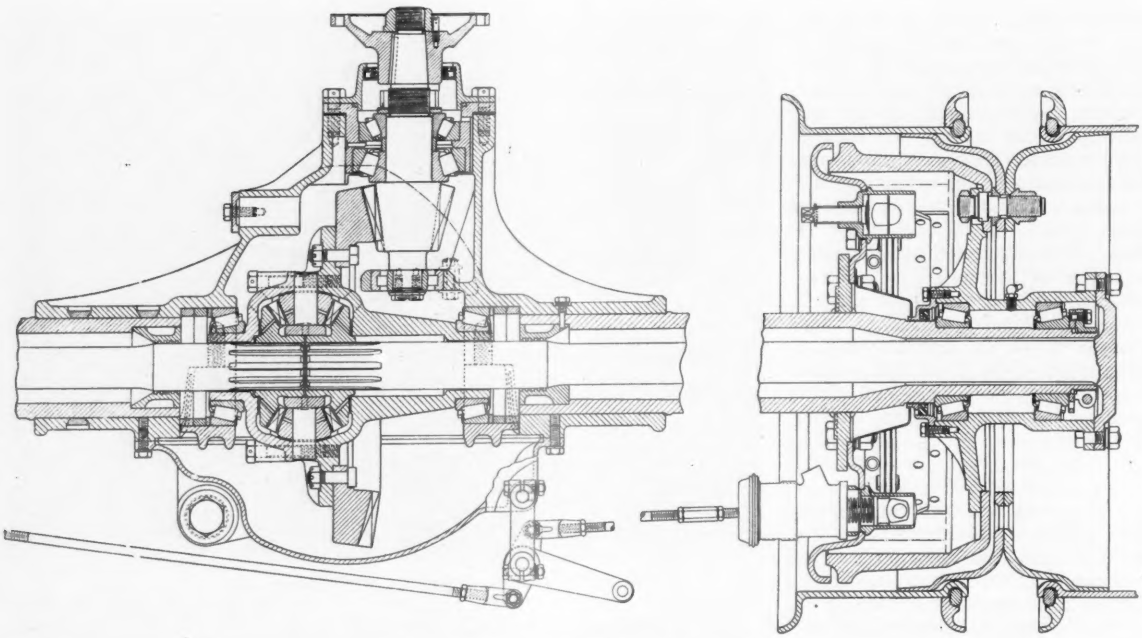
A five forward speed and reverse gearbox is fitted, dog engagement being used on top, fourth, and third gears. The ratios are as follows:—top 1:1, fourth 1·7:1, third 2·8:1, second 4·875:1, first 8·22:1, reverse 6·16:1. Though remarkably compact, the gearbox is generously proportioned, as may be seen from the general arrangement drawing. It should be noted that, in considering the gearbox, Thornycroft always refer to the mainshaft as the *primary shaft*.

The gearbox casing is cast in aluminium and has, on the lower portion of the near-side, towards the rear, a substantial-sized aperture which is normally covered by a blank plate, but can accommodate a tyre pump. The top of the gearbox casing is covered by the rectangular cast cover in which are disposed the three selector rods and which is secured by eight studs and nuts. On top of the front end of the cover is mounted the change-speed lever casing which, on this particular chassis, is extended well forward and upwards to bring the change-speed lever to the convenient position for forward control operation. On the top of the gearbox cover, to the front near-side, is the oil filler plug and a dipstick, the drain plug being at the bottom of the rear wall of the gearbox.

At the front of the gearbox casing the clutch shaft and pinion is carried in an 8in external diameter ball bearing and supports the front of the primary shaft by means of a Hoffmann L2102 bearing. The primary shaft is 2in diameter at the spline roots. At the rear end it is carried in a 3·5in external diameter ball race. After a plain washer, a Belleville washer and a distance piece, there is a small gear that drives the spur pinion from which the speedometer drive is taken. The primary shaft terminates in a taper to which is keyed the flange for the Layrub coupling at the forward propeller shaft. The flange is secured by a flanged locking nut and peg. Oil sealing at the rear end of the gearbox is by means of a Trist "Syntha"



General arrangement of gearbox.

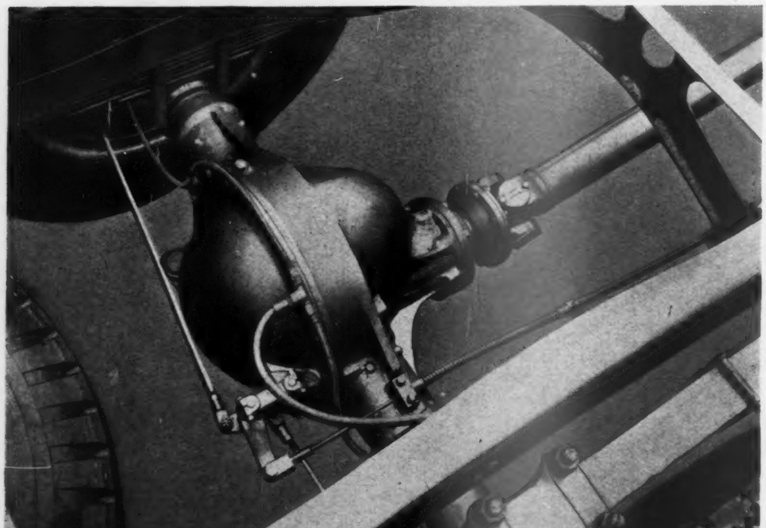


General arrangement of hypoid bevel rear axle.

double-lipped synthetic rubber oil seal carried externally by the extension of the rear cover which acts as a casing for the speedometer drive. The seal bears on the outer surface of the Layrub joint flange. The bearing surface for the seal is ground and then buffed. At the front end of the gearbox a projecting boss closely surrounds the square-cut return thread on the clutch shaft.

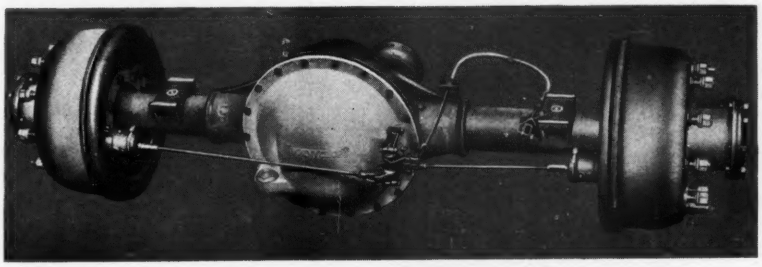
Engagement of top or fourth gear is by means of a sliding dog which has circumferentially cut teeth. The selector fork is mounted at the extreme front end of the selector rod and is directly engaged by the change speed lever. The fourth and fifth speed selector rod is in the central position and as gear engagement requires less than one inch of movement of the sliding dog, either side of the neutral position, the change between these two upper gears is particularly convenient. Each selector rod is located by a spring-loaded detent ball. Additionally there is an interlock between the three selector rods. This consists of a round-ended pin, free to slide through the centre selector rod until restrained by two hardened balls on either side which are brought up against the pin by movement of the selector rod on either side.

All gears are of nickel chromium case-hardening steel and have face widths of between 1in and 1·25in. They are tooth corrected after final machining to provide long life and silence in operation. The fourth speed primary gear has internal dogs to engage the sliding change-speed dog and has twenty-nine external teeth. It is carried on needle rollers 0·1875in by 1in. An inner race surrounds the run-out of the splines in the primary shaft. Both gear and needle rollers are held in position by a locating washer, shims and a Seeger circlip. Immediately behind this gear is a locating washer which, with its companion further back, hold in place the 0·1875in by 1·3125in needle rollers on which the third speed primary gear rotates. Both gears are drilled for lubrication of the needle rollers.



Rear axle and handbrake mechanism.

At the front end the layshaft is carried in a ballrace and at the rear end by a parallel roller race. The short reverse gear shaft is fixed, the gears revolving on Hoffman 1·2102 needle type roller races. Entry of the bottom of the change-speed selector lever to the first and reverse gear selector jaw



Complete rear axle assembly.

is restrained by a plunger stop and spring contained within the selector jaw itself. The oil capacity of the gearbox is 7 pints, and the makers recommend a lubricant of a specification approximating to S.A.E. 140.

Propeller shaft

A two-piece shaft of open tubular construction is used, and the front connection to the gearbox is by means of a Layrub 90 coupling. The other joints are of the needle roller bearing type. A flexible mounting is provided for the intermediate bearing.

Rear axle

The rear axle unit is particularly interesting in that it represents a complete breakaway from the type of rear axle so long associated with the heavier type of vehicle. Fully floating, it has a hypoid bevel drive in a built-up housing, the straddle mounted pinion being offset 1·750in below the centre line of the crown wheel. The drive ratio is 5·857 to 1, 41 teeth to 7. The centre portion of the axle housing is a well-proportioned steel casting, generally spherical in total form when the cover is in place. The main casting is, however, almost completely open at the back so that the drive unit is readily removable. From the production viewpoint, this large opening facilitates the machining of the interior of the casting where required. The cover for this opening is a large domed casting, secured by set screws. The bevel pinion shaft and its bearings are carried in a sleeve, detachable from the front.

Steel forgings are employed for the axle tubes pressed into the centre casting and plug welded. This type of construction was adopted to avoid the risk of distortion by welding the external joints. It also simplifies welding technique. The brake carrier flanges are steel discs secured in position by two fillet welds.

The bevel gear unit is mounted on two 5in external diameter Timken taper roller bearings which butt against a retaining ring and two distance pieces at either end. The ring and one distance piece at each end are constant in thickness, the other, supplied in different thicknesses, acts as a shim. Bearings and distance pieces are held in place on either side by a heavy malleable iron cap which covers half their circumference. It is thus a simple matter, provided that the axle shafts are not in position, to determine the lateral position of the crown wheel by choice of shim thickness.

Fitted close to the bearings in a machined enlargement of the end of the axle tube on either side is a sleeve machined with grooves to act as an oil seal against the enlarged inner end of the half axle shaft. The sleeves are secured in position by set screws passing through both axle housing and tube.

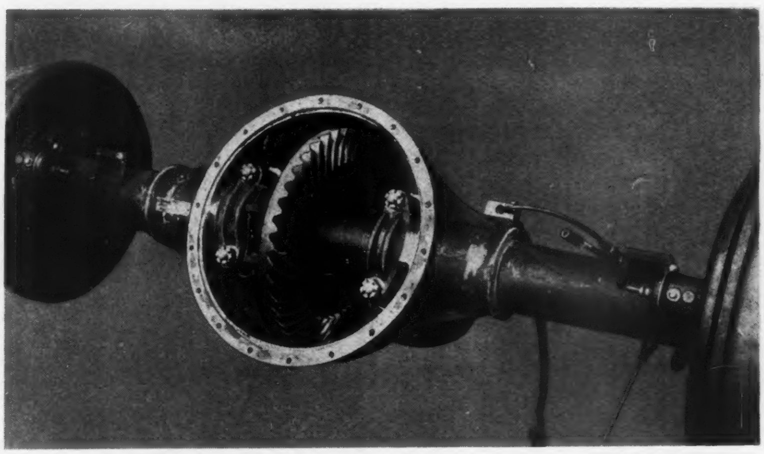
The cast steel differential casing is in two parts, the outer ends forming sleeves fitting the inner races of the Timken bearings. It is a four pinion unit, the pinions rotating on flat-headed hardened pins. Hard rolled bronze washers are fitted between the pinions and the casing. The halves of the pinion casing are joined by waisted studs and pillar nuts, wired for security. The 41-tooth, 15·5in diameter spiral tooth, hypoid bevel gear registers on the off-side differential casing and is secured by twelve 0·5in diameter fitted bolts, castellated nuts and cotter pins.

The bevel pinion and shaft are in one piece, the shaft diameter being 2in and pinion diameter 4·39in. The pinion shaft runs in two reversed Timken taper roller bearings which are mounted in a removable sleeve. The inner mounting to form the straddle is a parallel roller race positioned in an internal projection of the axle housing casting. A screwed sleeve and lock nut secured by a tab washer, lock the Timken bearings up against the pinion. The universal joint driven flange is attached by taper, and a spring-loaded lip-type oil seal is fitted in the retaining cap and bears on the outside of the flange casting.

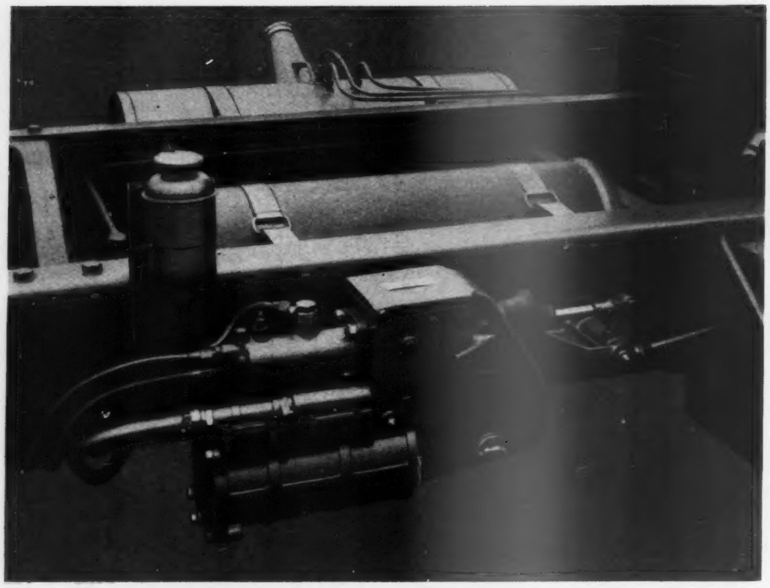
Mounted on reversed Timken taper roller bearings, the hubs are lubricated by a grease nipple that feeds into the annular recess between the bearings. A twin lipped "Syntha" seal is fitted in the inner cap to each hub, following a pair of sealing washers. The external bearings are secured in position by flange nuts and pinch bolts. The cast iron brake drums, which have an integral stiffening rib, are 16·25in internal diameter. They register on the wheel studs and are removable without disturbance of the hubs and bearings.

Front axle

Of conventional reversed Elliott type, the front axle is a 3 per cent nickel steel, I-section stamping, this section continuing right up to the swivel pin bosses. The two-diameter chrome steel swivel pin is secured in position by a cotter and nut. Phosphor bronze bushes are fitted top and bottom of the stub axle, the lower one



Crown wheel and differential assembly mounting.



Mounting of vacuum servo and brake master cylinder.

being flanged and held in position by the track rod steering lever which forms a bottom cover plate to the stub axle. Above the top bush is a taper roller thrust race, then a locking ring for the cap nut, then the cap nut itself. This carries a dowel screw to enter the appropriate hole of the locking ring which cannot turn on the swivel pin, as both have mating flats. The cap nut is split and is provided with a clamping bolt and nut. Finally, an aluminium cover is secured by set bolts to enclose the top assembly. It carries a grease nipple, there being a separate greaser at the bottom. The steering arm is bolted to a face on the appropriate stub axle according to the hand of steering. The swivel pins are inclined at 6·5 deg and the camber angle of the steering swivel is 1·5 deg. There is no castor angle.

Carried on opposed taper roller bearings, the front hubs are secured by an arrangement of clamping bolt and locking plate similar to those used on the swivel pins. The adjustment is intended for initial assembly rather than as a means of taking up wear occurring in service.

Both track rod and drag link are of tubular construction, no stampings other than the adjustment clamps being used. The result is a simple but robust unit that can readily be repaired in the event of damage, a valuable feature when vehicles are used overseas or where there is no ready access to spare parts.

Wheels and tyres

Dunlop wheels of three-piece pressed and welded construction are used. They are interchangeable, have a rim size of 6·00in × 20in, are 5·625in offset, and are secured by ten 0·875in diameter studs. On this vehicle 9·00—20/36in × 8in twin tyres are fitted as standard equipment, but 10·00—20in low pressure type can be fitted if desired. The spare wheel is normally carried under the rear end of the chassis frame.

Frame

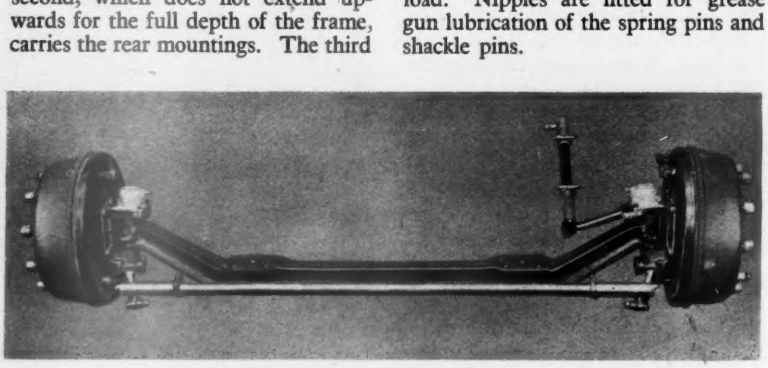
Of bolted construction, the frame has pressed steel side members 9·25in deep for the principal portion of its length, with a width of 2·75in at the central section tapering to 2·25in at the ends. The outer sides of the frame side members are parallel for the whole of their length and the rise over the rear axle is only 3in. There are five principal cross members, one in front of the engine to carry the forward mounting for the power unit, the second, which does not extend upwards for the full depth of the frame, carries the rear mountings. The third member supports the centre bearing of the two-piece propeller shaft, and the fourth and fifth are at the points of the rear spring anchorages. These two are of unusual construction, strengthening pieces fitting inside the side member channels at the spring anchorages having their flanges turned inwards. A simple pierced channel cross member is then bolted to these flanges.

There are no body attachment points, it being the maker's intention that bodies should be mounted on hardwood runners bearing directly on top of the side members and fastened thereto by U-bolts.

The main chassis dimensions are: wheelbase 13ft 6in, overall length 22ft 3in, overall width over rear tyres 7ft 3·5in, overall width of chassis frame 2ft 10in, front track 5ft 8·875in, rear track 5ft 7in, rear overhang 5ft, front overhang—measured to leading face of bumper bar—2ft 8·25in. The maximum recommended body space is 16ft 7in, the length from back of cab to centre line of rear axle being 10ft 6·5in. Overall height to top of standard cab is approximately 7ft 9in when the vehicle is in the unladen condition.

Suspension

Semi-elliptic springs 3in wide are used throughout, the fronts being 42in long and rear 50in at centres. The leaves are shot peened on the tension side. The front springs have normal camber whereas the rear ones are reversed. In each case the pivot point is in front, and the rear spring hangers are forgings, bolted by four fitted bolts through the web of the frame side member and the stiffener plate inside. The rear-end shackles are reversed Vee stampings. The front springs have ten leaves, the rear thirteen. The bottom three leaves of each spring are arranged in what is known as "progressive" form, i.e., they come into service with increasing load. Nipples are fitted for grease gun lubrication of the spring pins and shackle pins.



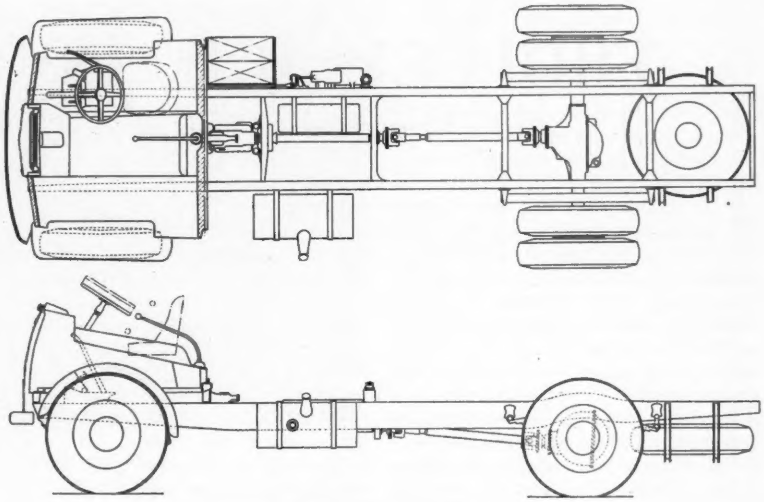
Front axle assembly and steering connections.

Brakes

Girling brakes of the two leading shoe type are employed. They are hydraulically operated by Lockheed equipment assisted by Clayton Dewandre vaccum servo. The vacuum servo and hydraulic master cylinder unit is mounted on the offside frame side member, with the brake fluid reservoir mounted nearby. Operation is by a rod from the foot brake pedal, then through a bell crank carried in a bracket which is bolted to the web of the frame member.

Vacuum is obtained by the rotary exhauster mounted on and driven by the engine. A large vacuum reservoir in the form of a circular steel tank is mounted between the offside frame member and the propeller shaft.

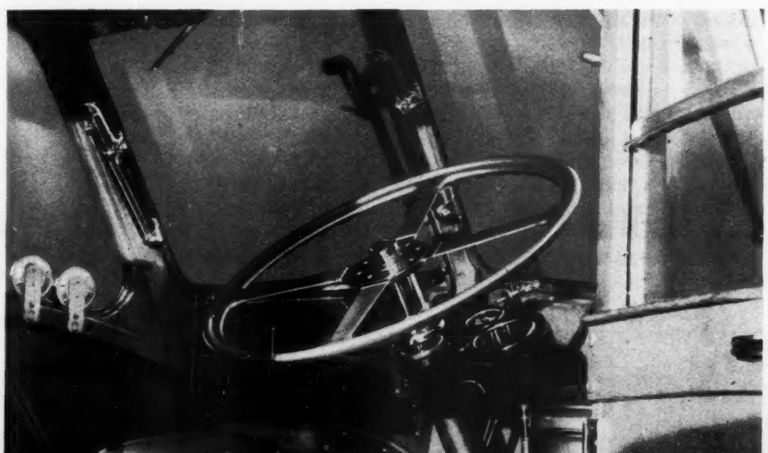
The effective dimensions of front brakes are: diameter 16in, lining width 3in. Rear brakes: diameter 16·25in, lining width 5in. The hand brake is simply the mechanical operation of the rear brake shoes. Application is by a rod to a hanging link positioned just in front of the rear axle, thence by a sheathed cable to a bell crank carried in a bracket mounted on the cover of the rear axle housing, finally by direct pull rods to the operating units. Brake adjustment is by a wedge unit.



Layout of Thornycroft 'Trident' chassis.

Steering

Marles cam and double roller steering gear is fitted, the ratio employed being 24·7 to 1. Noteworthy features are the fitting of a spring-spoked steering wheel and a telescopic adjustment at the top of the steering column which gives a 3in variation in the height of the steering wheel. The turning circle is 56ft for this 13ft 6in wheelbase model. The instrument panel is mounted high up on the front of the steering column.



Layout of cab showing controls and air silencer.

Miscellaneous

A Morris tube radiator with cast aluminium header and bottom tanks and side frames is carried on the front frame cross member by brackets sandwiched between rubber bushes. A fan cowl is fitted at the back.

Oil fuel is carried in a circular pressed steel tank, secured by steel straps to cradles bolted to the nearside frame member. Electrical equipment comprises 24-volt C.A.V. lighting and starting with compensated voltage control. The dynamo has an output of 288 watts and the 24-volt starter is of axial type. The two 12-volt 97 amp./hour C.A.V. type 12 CXBEW-11 batteries which are provided with teak cases are mounted on a pressed steel platform bolted to the off-side frame member immediately in front of the servo brake unit.

Cab structure

The cab base consists of a structure embodying the floor plates, engine cowling with cross-braced frame, head lamp brackets, and front wings. Attachment to the chassis is by means of four bolts in Silentbloc bushes. All electrical connections are through a ten-pin plug and socket system. Not only does this simplify cab building, but it renders it readily removable for servicing purposes. The standard cab is fitted with a fully trimmed bucket seat, adjustable for both height and leg reach. In conjunction with the adjustable, spring-spoked steering wheel it makes for driver comfort of a high order. To the front of the cab is fitted the radiator grille with a chromium-plated surround.

TROLLEY BUS EQUIPMENT

Little Change, but Steady Detailed Improvements

THE complete vehicles shown at Earls Court this year, though only eight in number, together with the five chassis, could be considered as representative of the requirements of both home and overseas markets. Those designed for use in this country were each completely equipped electrically by one maker, but in some cases, export models carry equipment by more than one maker—an arrangement between manufacturers and called the British Consortium formed to facilitate export trade. The five chassis on view were equipped by the B.T.H., G.E.C. and Metropolitan Vickers Companies. The English Electric Company and Metropolitan Vickers also had their own stands on which the working of their equipment could be demonstrated. Crompton Parkinson had their equipment on three complete vehicles shown respectively by Metropolitan - Cammell - Weymann Motor Bodies Ltd., Brush Coachwork Ltd. and Transport Vehicles (Daimler) Ltd., but the equipment was not shown otherwise.

B.T.H. equipment was fitted to the Sunbeam two axle chassis type MF 2 R and also to three complete vehicles on the Sunbeam stand. The Metropolitan Vickers installation was shown on the two Crossley chassis and on the Sunbeam three axle chassis. The English Electric Co. had their equipment installed on a three axle trolley bus on the B.U.T. stand and the majority of their equipment was also fitted to a B.U.T. chassis with a single deck body by Park Royal Vehicles and shown on their stand. The B.U.T. chassis type EBT is their two axle overseas model and has a wheelbase of 17ft. 6in. The overall length in this particular case is 32ft. which is 2ft. longer than permitted in this country for a two axle vehicle. As there are no restrictions to length in many countries, the chassis is designed for a maximum length of 33ft. and with the disposition of the units it is claimed that satisfactory weight distribution is obtained.

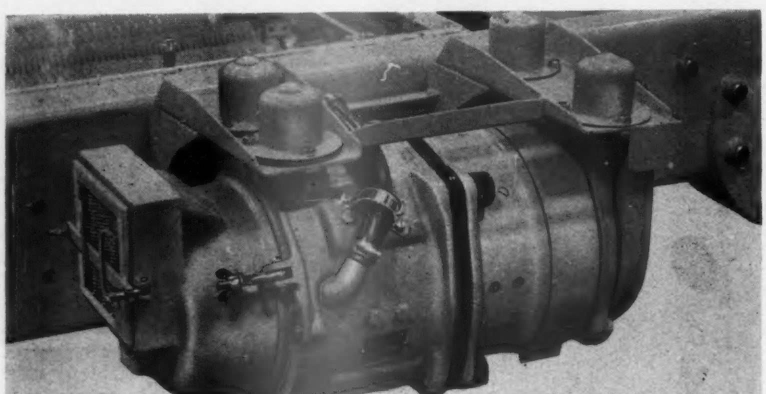
The electrical equipment is by the G.E.C. Company, the master controller being under the driver's seat and the complete contactor unit at the extreme rear end of the chassis, where it is readily accessible. The driving motor is installed a little behind the centre of the wheelbase on resilient mountings and offset 5in. from the centre line of the chassis. The drive is by tubular propeller shaft to the worm geared rear axle, which has a $9\frac{1}{3}$ to 1 ratio. Low pressure 11.00 × 20in. tyres are used all round, the rear ones being twin. The motor fitted is of 130 b.h.p. but the specially heavy duty Hardy-Spicer couplings and the worm driven axle with its 9in. centres make it possible to fit more powerful motors if required.

A 900 watt 12-volt C.A.V. lighting generator is mounted on the commutator end of the main motor, the shaft of which is extended to carry the smaller armature. Its frame is bolted to the end cover of the motor so that the whole machine overhangs from the driving motor. The generator is voltage controlled and has a cutting-in speed of about $3\frac{1}{2}$ miles per hour of the vehicle, the full output being produced at about twice this speed. A C.A.V. voltage control unit is fitted. The contactor unit and circuit breakers are enclosed in a built-up casing of sheet steel and are accessible from outside at the back of the vehicle by removing a covering panel. The contactors are the standard G.E.C. clapper type described previously.

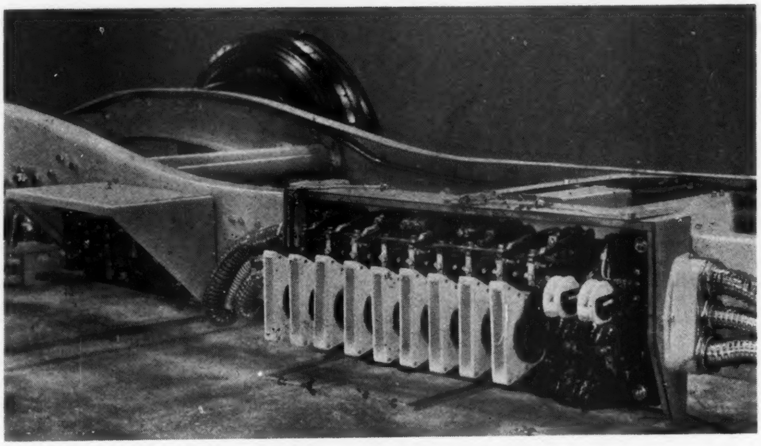
With a capacity of 5 c. ft. per minute the compressor unit operates the mechanical brakes. Its driving motor is a two pole totally enclosed type fitted with interpoles and designed to be switched directly on to the line. The complete unit is attached by resilient mountings to the outer face of a frame side member from which it is insulated both electrically and mechanically. Pressure is maintained at from 70 to 90 lb. per sq. in. in a 0.75 c. ft. reservoir mounted beside it.

A new design for overseas, the Sunbeam M.F.2R two axle trolley bus chassis has B.T.H. equipment throughout. It has been developed from the M.F.2B chassis previously described and is particularly suited for a single deck vehicle with front entrance body having large seating and standing capacity. The entrance is forward of the front wheels so that the seating accommodation is chiefly amidships. Weight distribution is improved by the position of the electrical components. The motor, which is the heaviest unit, is mounted at the back end of the chassis and the master controller at the front end below the driver's seat. The main contactor panel is attached to the outer face of the left chassis member about midway between the axles. The automatic accelerator relay panel is between this and the front axle and the lighting motor generator to the rear and in front of the back wheels. The right hand chassis member carries the compressor unit and air reservoir. As these units are all attached to the outer faces of the chassis members they are readily accessible. The main resistances are in two sections and are carried between the side frame with the small shunt resistance unit in front.

With an overall chassis length of 33ft. 3in. and a width of 8ft. between the outer faces of the rear tyres, the wheelbase is 17ft. 6in. The wheelbase can be increased to 18ft. 6in. and the overall length to 34ft. if required.



B.T.H. motor generator on Sunbeam chassis.



B.T.H. control unit on Sunbeam chassis.

All wheels are interchangeable and are fitted with 11.00in. × 20in. tyres.

From the motor, the drive is taken forward to the back axle by a tubular propeller shaft. The axle has an underslung worm drive with a ratio of 9.66 to 10.33 as required. The motor shown was of 115 h.p. but higher powers up to 140 h.p. can be installed. A large duct with a rectangular screened intake at the extreme rear end of the chassis below the body admits filtered air which is drawn through the motor by a silent fan at its driving end.

Mounted as a self-contained unit the master controller and reverser type C679 is under the driver's seat and operated by a pedal. It includes the accelerating controller and reverser and also the braking controller, all of which are interlocked with each other. The consecutive stages of operation have been previously described with reference to the combined unit type TBC. The stabilised rheostatic system of braking is used and there are two stages of electric braking available before mechanical braking is introduced. The second stage gives the maximum braking torque allowed by mechanical considerations. The contactor panel type R.M.C. is arranged as a separate unit though operated by the master controller. The contactors are the standard B.T.H. clapper type as previously described.

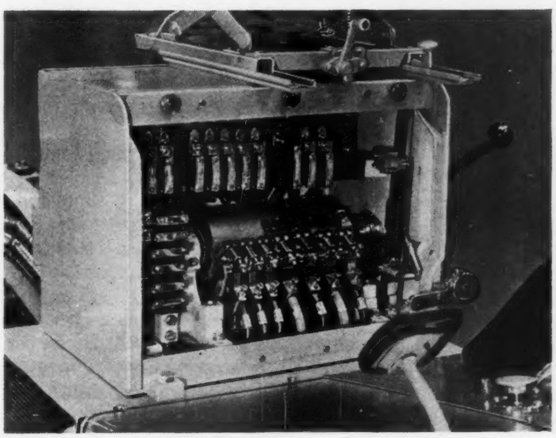
Operated through a combination of time and current relays, the automatic accelerator panel has also been previously described. There are four electrically operated relays and the steps are arranged to give smooth acceleration at a maximum rate controlled by the setting, though the driver may notch up at any lower rate.

A single unit having two armatures mounted on a single shaft, the motor generator has the high and low tension parts insulated from each other. The motor is series wound and drives the shunt wound generator. Voltage regulation is used and both machines are cooled by a single fan at the generator end. This fan also can limit the speed should the generator become open circuited for any reason, such as the breakage of a lead or the battery becoming disconnected.

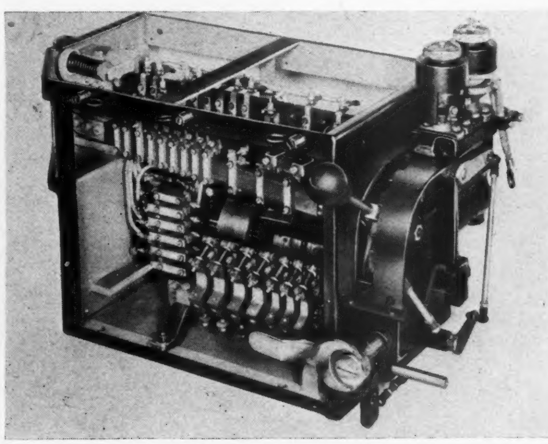
Equipped throughout electrically by the Metropolitan Vickers Company the Crossley "Empire" model two axle trolley bus chassis is designed for double deck bodies. It has a wheelbase of 16ft. 1½in. and an overall length of 24ft. 11in. The tyre sizes are 11.00in. × 20in. on front wheels and 10.00in. × 20in. on the twin rear wheels.

Mounted on the bulkhead inside the cab at the side of the driver the combined master controller and switch group unit embodies all the control units for operating the vehicle. The traction motor is mounted on Silentbloc supports midway between the axles and is offset from the centre line of the chassis. The drive is taken by a tubular propeller shaft to the worm geared axle which has a ratio of 9.33:1.

The master controller and braking controller are operated directly from the two control pedals to which they are connected by linkage. Contacts of the scissors type are used, the reverser being of the drum type and operated by a separate lever. All the controls and switching for the operation of the vehicle are enclosed in the controller, which has ten steps from rest to full speed. The first step closes two line contactors connecting the armature with its series field and including the whole main resistance in series with them. A resistance is at the same time connected in parallel with the series field. The second step cuts out this latter resistance and switches in the shunt field. From the third to the sixth step the main resistance is cut out in progressive stages, so that at the seventh step all the main resistance is cut out and the motor with its full shunt and series fields is connected to the line. The eighth step cuts out the shunt field and the ninth and tenth connect resistances in parallel with the series field, progressively weakening it still further and giving the highest speed.



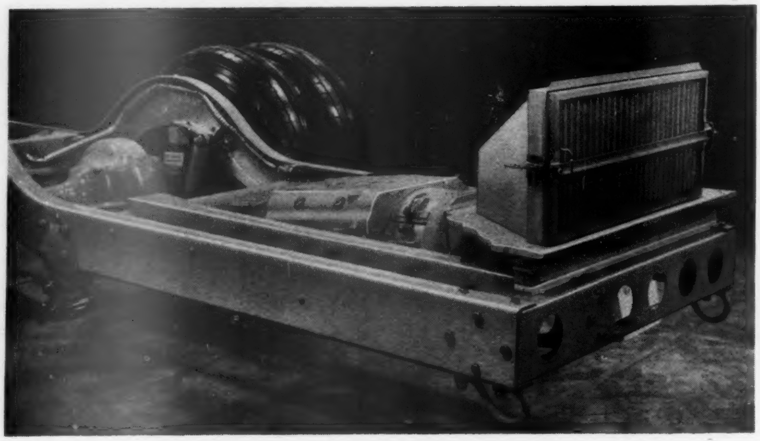
B.T.H. master controller on Sunbeam chassis.



Metrovick master controller on Crossley three-axle chassis.

Battery manoeuvring connections are included and are brought into operation by moving the reverser handle to either the "forward" or "reverse" battery position and operating the battery series-parallel switch by means of the special key provided. This key also forms part of an interlock which prevents the reverser being moved to the trolley positions during battery manoeuvring. The accelerating controller and the reverser are also interlocked to prevent the reverser being moved when the controller is not in the "off" position, thus providing a safeguard against current being broken by the reverser contact.

In the control unit is the automatic acceleration unit consisting essentially of (1) a spring-loaded telescopic link connecting the master controller and the power pedal, (2) a current limiting relay and (3) an oil dashpot incorporating two magnetically operated valves and two needle valves. In operation the telescopic link provides an elastic connection between the power pedal and the master controller and allows the pedal to be fully depressed though the controller can only advance under the action of the telescopic link springs at a rate determined by the motor current and an over-riding time control. If desired the controller may be operated step by step at any lower rate, since the automatic device does not come into action until the driver tries to accelerate at an excessive rate. When this device is fitted it is not possible to overload the motor, so that an overload relay is not required. A special feature of this particular system is the hill climbing valve which ensures that the progressive advance of the controller is never completely stopped so that on the steepest gradients it is almost impossible for the vehicle to stall. It is claimed that the viscosity of the dashpot oil remains sensibly constant over any range of temperature likely to be experienced, so that the rate of acceleration permitted is unaffected by normal temperature changes. All contactors are clapper type units having an efficient blow out circuit incorporated in their design and they are so arranged that all connections are made in front of the panel. The interlock assembly is also constructed on the unit principle, the fingers being mounted on a moulded bakelite block which is removable from the front of the panel without disturbing the contactor. The fingers are self-aligning and pure silver contacts are used.

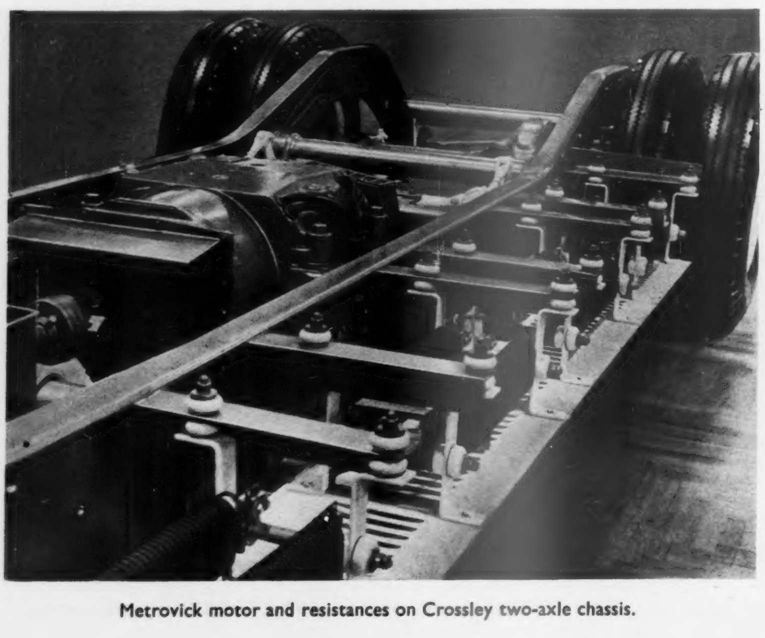


Rear mounted B.T.H. motor on Sunbeam chassis.

Stabilised rheostatic braking is used though the contra-field system can be fitted if preferred. In both systems braking is applied in two distinct and progressive stages during the initial movement of the pedal. The rheostatic system operates by energising the motor shunt field from the line through a portion of the main resistance and disconnecting the series field. The armature is connected across the whole series resistance for the initial stage of braking and the current it generates passes through the whole resistance including that portion which carries the energising field current from the line. The voltage applied to the field is in consequence equal to the live voltage less the drop in voltage across the common section.

Any tendency towards a high braking current corrects itself by reducing the voltage available for energising the shunt field. Similarly a fall in braking current increases the voltage across the shunt field. The effect of the arrangement is to maintain a substantially constant value of braking current over a wide range of speed. A second step giving increased braking torque is obtained by cutting out a portion of the main resistance common to both the field and armature current. The braking effort is then stabilised at a higher value depending on the value of the common resistance left in circuit. The contra-field system referred to previously obtains the same stability by utilising the motor series-field to oppose the shunt field which is energised from the supply line. The main resistance in this case, however, is isolated from the live voltage during braking which has certain advantages in bad weather.

The main motor is the Metrovick type M.V.209 having a one hour rating of 105 h.p. The motor is compound wound and is flood proof up to the centre line. It has four supporting arms which are bolted to rubber



Metrovick motor and resistances on Crossley two-axle chassis.

Metrovick control unit on Crossley two-axle chassis.

resilient mountings in the brackets attached to the chassis.

Also Metrovick R.P. type, the main resistors are made of aluminium chromium alloy steel strip which has a high specific resistance and negligible temperature coefficient. The strip is edge wound on ceramic insulator supports and the units are mounted in frames attached to the left side chassis member. A 12-volt C.A.V. generator is direct coupled to the traction motor so that it overhangs at the commutator end. It has an output of 1800 watts at 30 volts and a cutting in speed of about 4 miles per hour. A C.A.V. voltage control and cut-out are used.

On the Crossley stand the three axle "Dominion" model carried the complete Metrovick equipment which differed only in detail from that fitted to the two axle "Empire" model. For instance, a separate master controller and switch group are fitted but both units are mounted in the driver's cab. The main motor is the Metrovick type M.V.210 with a one hour rating of 125 h.p. Both this and the M.V.209 are flood proof up to the centre line and the air inlets are flanged to carry an air filter or trunking if required. The motor frame is fitted with four supporting arms which are bolted to rubber resilient mountings in the chassis brackets.

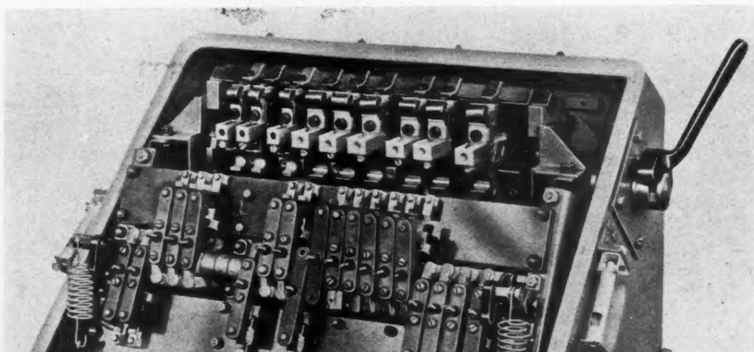
The motor generator is the Metrovick-C.A.V. type A.Y.29 and has an output of 1200 watts at 30 volts. It consists of a series motor and a shunt generator the two armatures having a common shaft. The motor and generator yokes are assembled together with moulded mica insulation at the joint and the motor armature is built on a sleeve carried on the common shaft and insulated from it by moulded mica cones provided with long creepage surfaces. The bearing at the motor end is insulated from the frame by moulded mica, which completes the secondary insulation between the two portions of the set.

A fan at the generator end draws air through the machine for cooling and also acts as a speed limiter. Since the motor is series wound the speed variation due to alterations in line voltage is negligible and that due to load variation has been kept small by design. The generator is an eight pole machine, shunt wound, and operates with the standard C.A.V. battery cut-out and voltage regulator. The unit is carried on resilient mountings and is flood proof up to the centre line.

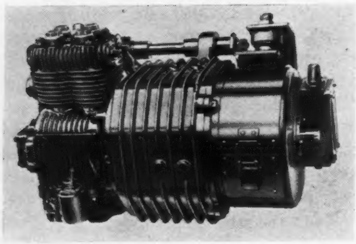
The Sunbeam S7 three axle chassis is fitted with a Metropolitan Vickers cab control unit, combining the master controller and switch group in a single dust-tight metal case. All necessary equipment for manoeuvring the vehicle on batteries is also included. The forward and reverse battery positions are obtained by placing the reverser handle in the appropriate position. This action simultaneously alters the power connection, bringing the two halves of the battery in series and so avoids fitting a separate series-parallel battery switch.

Automatic acceleration as described above, is fitted to the equipment. The main resistors are the Metrovick continuous strip type fitted in two frames amidships between the main chassis members and in front of the traction motor. This motor is the M.V.210 type compound wound, with an overhung generator of 1800 watts at 30 volts, using a C.A.V. voltage regulator and cut out. The motor has a one hour rating of 115 h.p. and is flood proof, the commutator covers of both motor and generator being sealed and the air inlet well above the centre line. The remainder of the equipment is similar to that already referred to and stabilised rheostatic braking is used in this case also.

Park Royal showed a single deck trolley bus mounted on a B.U.T. three axle chassis fitted with composite electrical equipment by Metropolitan Vickers and the English Electric Company, the latter being responsible for the master controller and contactor units with all their equipment. These components differ from those previously described in that the master controller alone is mounted in the driver's cab, and the complete contactor unit across the rear end of the chassis. The contactors and all accessories are now mounted in line and are accessible from outside. The master controller operates on the rocking lever principle as previously described and



G.E.C. master controller on B.U.T. chassis.



G.E.C. Westinghouse air compressor unit on B.U.T. chassis.

has butt type contacts with mechanical wiping action to preserve the surfaces. All contacts are of de-oxidised silver.

Cam operated, the reverser embodies the contacts for battery manoeuvring and also for a runback brake, which comes into action if the power supply fails or the trolleys dewire. It is operated by a contactor which is normally in the closed position and is only held open when its operating coil is energised from the line. The contactors with their interlocks mounted on moulded insulators are unchanged from those previously described. The usual electrical interlock is provided in the master controller to cut off the power before the brake can be applied should the power pedal still be depressed. There are ten stages of acceleration and the series field only is used. In the early stages the main resistance in series with the motor is cut out in progressive stages and in the last three the field is weakened by connecting resistances in parallel with the field. It is interesting to note that the shunt field is not employed at all in this system during acceleration.

Two stages of rheostatic braking are employed, the shunt field alone being used. The armature is disconnected from the line and re-connected through a contactor across a portion of the main resistance, the series field being excluded from the circuit. The shunt field is then connected to the line in series with a resistance which is cut out in two stages and increases the braking torque by strengthening the field and so maintains the torque as the motor slows down. A differential effect which stabilises the action is obtained by connecting the shunt field to the line through a section of the braking resistance so that the potential across that portion of the main resistance due to the braking current, opposes and limits the shunt field current and so limits the rise in braking current.

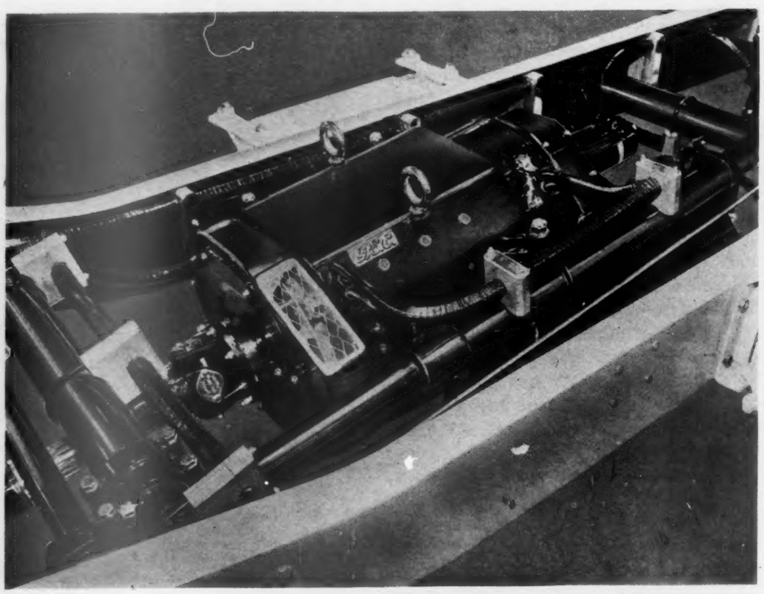
The Crompton Parkinson equipment was installed on three complete vehicles, two of which were mounted on B.U.T. three axle chassis and one on a Daimler three axle chassis. The equipment includes Crompton Parkinson motor with Allen West control gear and is substantially the same in the three installations. The complete control unit is mounted alongside the driver's seat on the left side of the vehicle and is connected by resilient mountings to the front bulkhead and floor members. Included on the panel are main contactors, shunt field contactors, field diverter contactors, the power master controller with automatic accelerating unit, brake master controller, the main reversing switch, series parallel battery switch and contactors for battery manoeuvring. Controlled rheostatic braking is used and the compound field is employed for accelerating, the shunt field being a sufficiently small proportion of the whole to avoid generating high voltages. As far as could be seen the details of this equipment do not appear to have been changed in any way from those previously described.

In the thirteen complete vehicles and chassis exhibited this year, it is interesting to note that there was not a single instance in which the contra-field system of braking was installed, the stabilised rheostatic control being employed in all cases. Fluorescent lighting does not seem to be making the progress that might be expected considering the quality of the illumination and its high basic efficiency.

The C.A.V. system with vibrater-choke units in each lighting circuit has already been referred to and now Metrovick are producing a motor generator unit designed to run off the battery of the vehicle. The unit consists of a two bearing machine with a D.C. generator and a two phase alternater in a common frame. As the alternater is of the inducter type, the windings are stationary so that sliprings are not required, the output leads being taken direct from the windings. It runs at 4,800 r.p.m. and has a 400 cycle A.C. output of 360 watts at 110 volts. The normal voltage of the motor is 24 but other voltage motors can be supplied. The machine is cylindrical in shape with a diameter of 7⅞in. × 12½in. long with a total weight of 35 lb. It is carried on rubber mountings and can be mounted on the chassis or inside the vehicle.

At the high frequency of 400 cycles, choke stabilization and resonant starting is satisfactory and each lamp is fed through a choke with a capacitor across the filament to provide the resonant circuit. The machine is usually started up with the lamps in circuit so that the gradual increase in voltage can heat up the filaments before reaching a figure sufficient to initiate the discharge. In the case of individually switched lights a special choke is used to heat up the filament before the full voltage is applied.

Series capacitors are connected in one lead from each phase of the alternater to compensate the internal reactance drop and the lamp current is maintained at a fairly constant figure in spite of battery voltage fluctuation. Tungsten lamps at the usual rating consume about 3.3 times as much energy as fluorescent tubes having the same light output so that even with a conversion efficiency of, say, 75 per cent. the gain is only reduced to about 2.5 so that quite a small machine is required.



G.E.C. motor on B.U.T. chassis.

MATERIALS HANDLING

A Review of the Methods and Equipment in the New Vauxhall Factory

TO modernise, and also to expand their production capacity, Vauxhall Motors Ltd., Luton, have undertaken a programme that will take three or four years to complete at a total cost in the region of £11,000,000. The first stage in this programme is now nearing completion. It is a new factory building with a floor area of 19½ acres. The greater part is devoted to functions in connection with Bedford vehicles. At the moment all detail machining of Bedford parts, engine, axle, cab and body assembly and the main assembly line for these vehicles are in operation. In addition, the gear production for commercial vehicles is being carried out in the new factory. Shortly, it will also house detail machining and the assembly line for passenger car engines and the production of passenger car gears.

Already some 1500 machine tools have been installed and are operating. Most of these machines are new. Many are of standard types, but there are also many that have been specially designed for use in this factory. These notes, however, are not concerned with actual machining operations, which will be dealt with at a later date, but only with the general lay-out and the methods of material handling that are employed.

The factory itself, see Figs. 1 and 2, is all on one floor, except for a basement store at one end with an office block above. Apart from space for a surgery, a cafeteria, ablutions and showerbaths, the whole of the floor area is devoted either to stores or to actual productive functions. The main stores area runs longitudinally down one side of the building for about a quarter of a mile. In general, the machining and sub-assembly lines run transversely across the building and the main assembly lines run longitudinally, so that material progresses in a relatively straight line from the stores towards the main assembly lines. A diagrammatic sketch of the factory lay-out is shown in Fig. 3.

Before the various sections are considered in some detail, it may be as well to state two general principles that have been applied. The first is that the handling of individual components must be avoided. To meet this principle, all parts are stored and moved either in standard containers or on pallets of Vauxhall design. Containers are made in two sizes, 8 and 20 cubic feet capacity, and the size, weight and bulk of any component determines the type of container to be used. These containers, 6,000 in all, are so designed that they can be stacked one on top of another so that full use can be made of vertical storage space. One loaded container constitutes a "unit load".

For short journeys up to 250ft. the movement of unit loads is effected entirely by fork trucks. Fifteen 6,000 lb. fork trucks that can lift up to 12ft. high are already in operation. Eventually there will be 20. Certain components are handled on pallets by a special crane fork of Vauxhall design that slides under the pallet in the same manner as the prongs of a fork-lift truck. It is self-balancing and does not need to be secured. This crane fork enables palletised loads to be rapidly removed from supply vehicles when the load is of a type not accessible to either fork truck or standard hoisting tackle.

The second general principle that has been applied is that wherever possible the distribution of individual unit loads must be avoided, because it is more economical to move multiples of unit loads. This calls for the use of shop-tractor-and-trailer trains. For unloading lorries and for moving unit loads between groups in the storage area, Lansing-Bagnall powered hand-trucks are used.

An interesting development for handling incoming goods is a device known as the "dock leveller". It is an

Fig. 1. The new, 19½ acres, factory building at Vauxhall Motors Ltd., Luton.

Fig. 2. An interior view of the factory.

hydraulic device that allows the height of the receiving bay to be adjusted to that of the vehicle to be unloaded. As a result, hand trucks or fork trucks can be run right into the vehicle, thus eliminating a great deal of handling. This is the first installation of such a device in the United Kingdom, although such devices have been used for some time in the United States of America. It is so constructed that it transmits no weight to the vehicle. The weight of the unloading truck is borne by the leveller itself. Furthermore, as the height of the vehicle floor rises as loads are removed, the height of the dock leveller is automatically adjusted to suit.

Maximum efficiency in handling incoming goods does necessitate co-operation from the suppliers, and Vauxhall Motors Ltd. encourage their many suppliers to forward material in standard containers so that the goods are received as unit loads. Eventually, it is expected that some 80 per cent. of all materials from outside suppliers will be received as unit loads.

The main stores area is so placed that no component need be moved more than the width of the building. In this area, 2,000 different components are handled. In addition, there is a basement store of 77,000 square feet area at one end of the building. This is used for storing standard parts such as washers and screws, which are distributed to the production sections in metal "tote" pans.

Production Areas

A point that may cause some comment is the sparing use that is made of overhead conveyors either for feeding or storage. In comparison with another newly-equipped factory, Fiat-Mirafiori, which was described in the combined September/October 1950 issue of this journal, there is a very great difference in the number and lengths of overhead feeder conveyors. Briefly, it may be said that the Vauxhall materials handling engineers consider that the necessity for an overhead feeder conveyor is a sign that the plant lay-out departs from the ideal, which is that the work should progress in such a manner that when one process is completed, the part is adjacent to the station for the next process. With so many different components and processes to be considered, it is not possible to obtain a lay-out that will completely obviate the necessity for certain parts to move relatively lengthy distances between

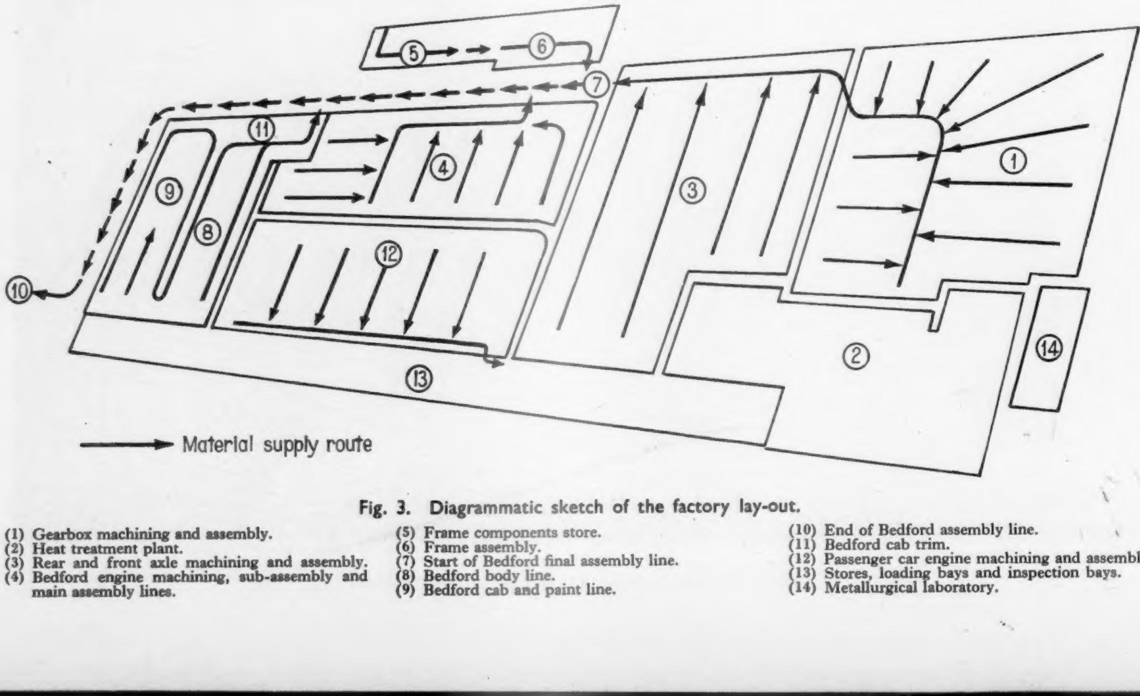


Fig. 3. Diagrammatic sketch of the factory lay-out.

(1) Gearbox machining and assembly.
(2) Heat treatment plant.
(3) Rear and front axle machining and assembly.
(4) Bedford engine machining, sub-assembly and main assembly lines.
(5) Frame components store.
(6) Frame assembly.
(7) Start of Bedford final assembly line.
(8) Bedford body line.
(9) Bedford cab and paint line.
(10) End of Bedford assembly line.
(11) Bedford cab trim.
(12) Passenger car engine machining and assembly.
(13) Stores, loading bays and inspection bays.
(14) Metallurgical laboratory.

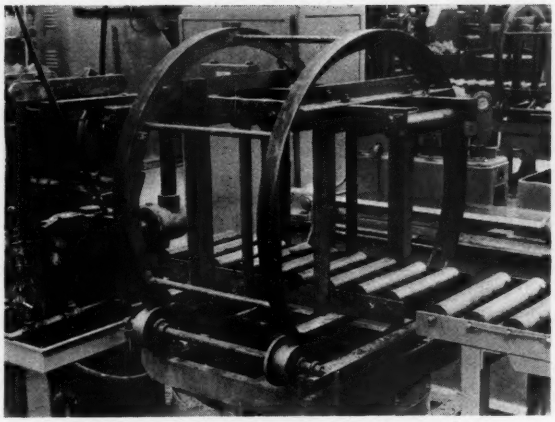


Fig. 4. Roll-over device in the machine conveyor line for cylinder blocks.

operations, but there has been a near approach to this ideal so that there is but little need for storage and feeder conveyors.

Before the various power-operated conveyors are described, it is worth stressing that every care has been taken to ensure easy handling, particularly of the heavier components, during the machining operations. Wide use is made of simple roller conveyors for transferring components from one machine to the next. On the machine lines for the heavier components such as cylinder blocks and heads, there is a constant loading height and in every possible case the work-holding fixture is open-ended so that the component can be pushed in at one end, and when machining is completed pushed out at the other end. Therefore, in effect the work fixture becomes part of the conveyor line and there is complete straight line flow. An interesting development to facilitate loading and unloading work fixtures is the incorporation of rollers in the base of the fixture. Another interesting development to facilitate handling of cylinder blocks is a roll-over fixture of the type shown in Fig. 4, which is used when the block must be turned to bring another face into the machining position.

In general, the machine lines for the heavier components are laid out in such a manner that at the completion of the machining sequence the component reaches an inspection station adjacent to the start of the appropriate assembly line. The roller conveyor for the machine line is continued to this inspection station.

Heat Treatment

The heat treatment department is equipped to deal with the whole of the production from this factory for which any treatment is necessary. It includes carburising, re-heating and tempering furnaces with all the necessary ancillary equipment such as a plant fcr producing protective atmosphere gas, shot blast equipment and quenching presses to eliminate gear distortion. One section is laid out for cyanide hardening and a smaller one for induction hardening. In each section the maximum use is made of mechanical handling aids.

In the main section, that devoted to carburising, the carburising compound is delivered mechanically to three overhead hoppers above the filling stations. It can be drawn as desired to fill the pots. Packed pots are transferred from the filling station to a charging machine which serves the three carburising furnaces. These are all of the continuous type with the pots conveyed mechanically through the furnace. On leaving the furnace the pots pass through a cooling chamber and finish beside another charging machine ready for unloading. Empty pots return to the filling station down a gravity roller conveyor.

From the charging machine at the discharge end of the carburising furnace, the pots are transferred to a gravity roller conveyor on which they travel back to a wire mesh cooling conveyor for final cooling of carburised parts. The contents of the pot, that is, the components and the carburising compound, are tipped on to the wire mesh conveyor. The compound falls through the wire mesh into an elevator and travels in overhead screw conveyors to the filling hoppers. Meanwhile, the components are carried on the conveyor to the re-heat furnace, being cooled on the way. After they are tipped, the pots go back to the filling stations on the same charging machine as is used for taking the filled pots to the furnace.

Re-heating and tempering furnaces are arranged in pairs. The work passes through these furnaces, which are all of the pusher type, on trays. For each pair of furnaces there is a roller conveyor along which the trays, after they have been emptied, are returned from the discharge end of the tempering furnace to the charging end of the re-heat furnace. On the cyanide hardening section there is a power-pulled overhead. It is 376ft. long and runs at 2ft. 5in. per minute. This conveyor carries components on jigs from the cyanide hardening section to the tempering furnaces through a washing machine, and from the tempering furnaces back to the jig loading and unloading benches.

Practically all the components for heat treatment come from the detail gear machining section. Special precautions are taken in transporting cut gears to the heat treatment section. It is important that the teeth of the gears be preserved from the danger of accidental damage. To this end special frames have been constructed for the transport of gears to the hardening

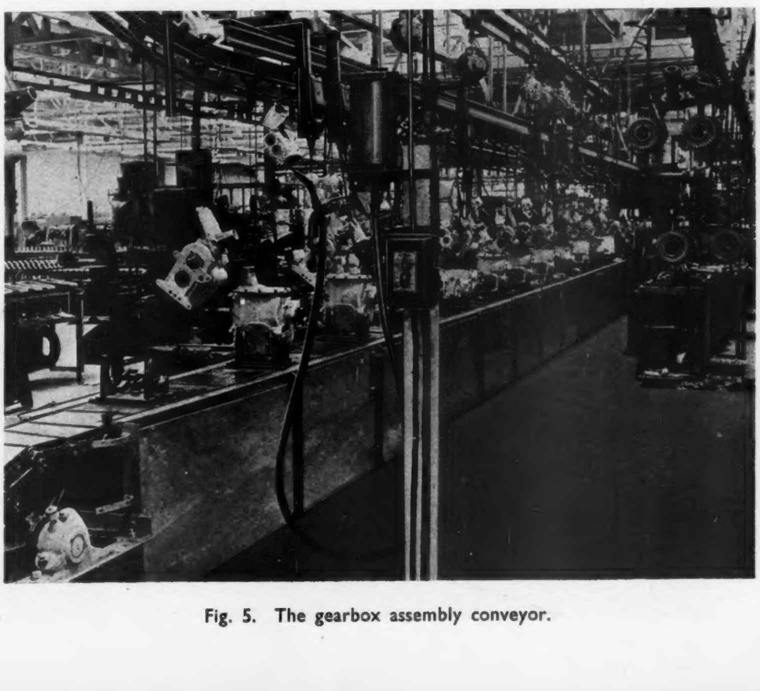


Fig. 5. The gearbox assembly conveyor.

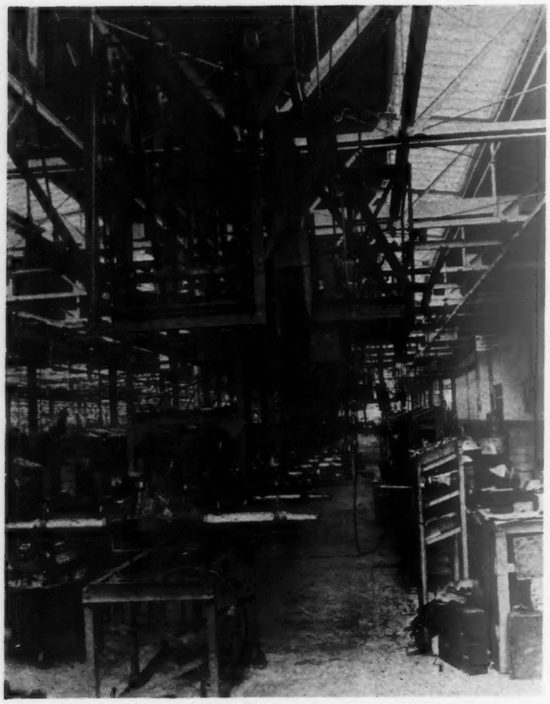


Fig. 6. Loading end of the flight conveyor for back axle assembly.

section. These are timber frames of A shape. Each one is mounted on a four wheel bogey and is constructed to carry a number of gears, with each gear in its own individual recess so that there is no danger that during transport wheels will knock against each other and cause damage.

When all the work has been completed on the gears and shafts they are transferred to an inspection station. At this station they are loaded on to a power-pulled overhead conveyor 544 ft. long. It runs at 8ft. per minute and conveys the components in sets to the gear box assembly conveyor. Special carriers spaced 2ft. apart carry the components. A complete set of shafts and gears is carried on two consecutive carriers.

Meanwhile another power-pulled overhead conveyor is transferring gearbox casings and covers to the gear box assembly conveyor from the detail machining section. This conveyor is 412ft. long, runs at 6ft. per minute and has carriers spaced at 2ft. 0in. Eventually there will be two gear box assembly conveyors, one for passenger car boxes and the other for commercial vehicle boxes. The gear and shaft conveyor and the gearbox casing and cover conveyor will serve both assembly conveyors. At present only the commercial vehicle gearbox assembly conveyor is installed and in operation.

Gearbox assembly is carried out on a slat and jig conveyor shown in Fig. 5. The illustration also shows the power-pulled overhead feeder conveyors with gears and shafts and gearbox casings and covers. Sub-assemblies are made on benches conveniently placed beside the conveyor which is 70ft. long and runs at 16in. per minute. All the necessary hand tools, nut-runners and the like, are suspended from spring balances at appropriate points above the conveyor. At the end of the assembly conveyor every gearbox is given a running test and then is transferred by hoist to a power-pulled overhead conveyor for transfer to the engine assembly section.

The overhead conveyor for carrying commercial vehicle gearboxes to the engine assembly is 1012ft. long, runs at 10ft. per minute and has carriers spaced at 30ft. pitch. It was originally intended to act as a schedule-timed conveyor that would deliver a gearbox for a specific engine at exactly the right moment to synchronise with the engine assembly conveyor. However, a great number of Vauxhall commercial vehicles are exported in the completely knock-down condition and the conditions arising from this are such as to make it difficult to employ a schedule-timed conveyor. It has therefore been decided to modify this conveyor and make it a feeder and storage conveyor with carriers spaced at 3ft. 4in. pitch and with the speed increased to 30ft. per minute.

When the factory is in full production there will be a power-pulled overhead conveyor for transporting passenger car gearboxes to the passenger car assembly conveyor. It will be 1440ft. long with carriers spaced at 3ft. 4in. and will have a speed in the order of 20ft. per minute.

Front and back axle assembly functions are also carried out on assembly conveyors. For the back axle assembly an overhead conveyor of the flight-bar type is employed. The loading end of this conveyor is shown in Fig. 6 and the unloading end in Fig. 7. It is the only overhead conveyor that is used for assembly functions. An overhead flight-bar conveyor is used because the use of a floor conveyor built to a convenient height for working would have necessitated a pit to take the return run. It also has the advantage of allowing easier access to the axle for assembly

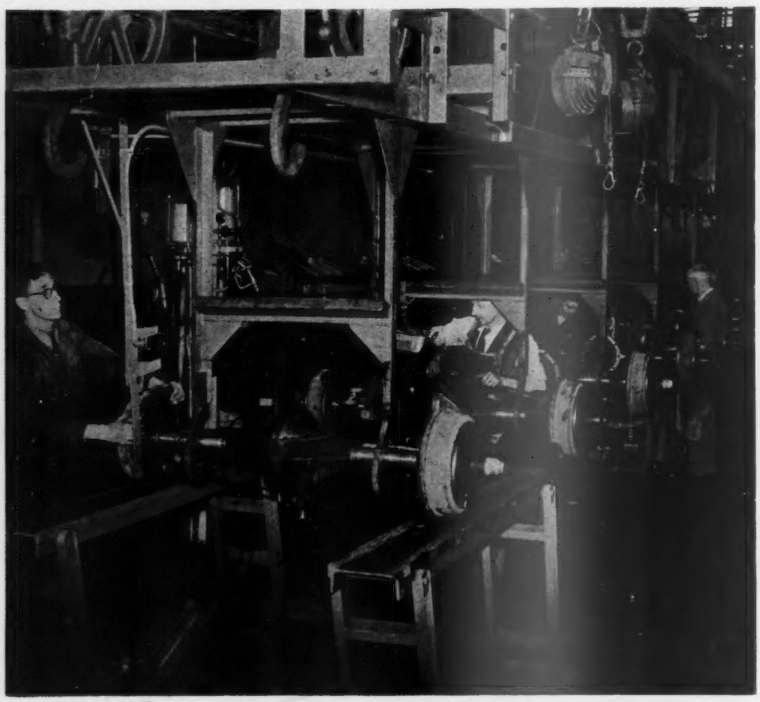


Fig. 7. Unloading end of the back axle assembly conveyor.

Fig. 8. Front axle assembly conveyor.

Fig. 9. The engine assembly conveyor.

Fig. 10. The start of the motoring section of the engine conveyor.

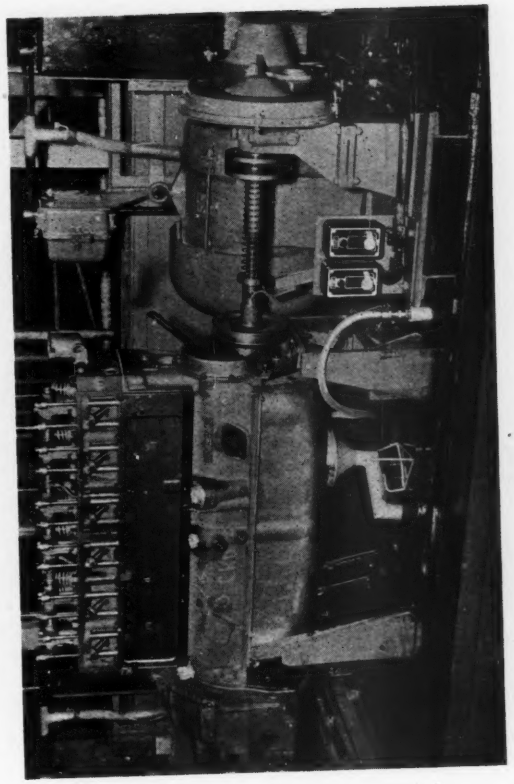


Fig. 11. Motoring an engine as it passes along the conveyor.

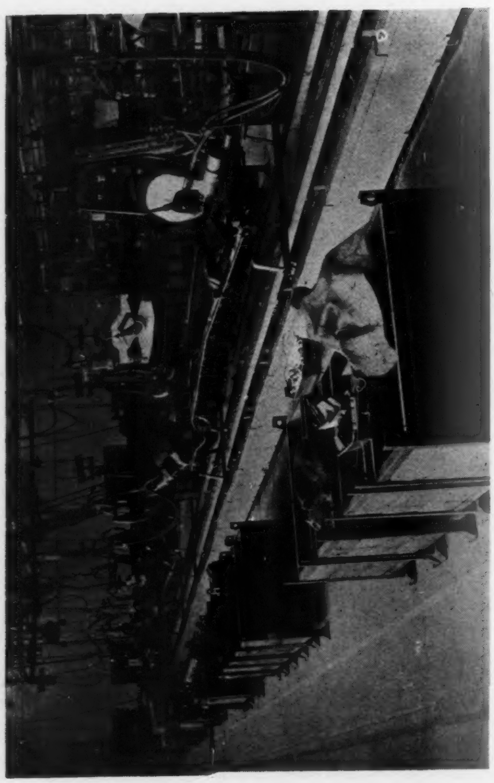


Fig. 12. Frame assembly conveyor.

Fig. 13. Mounting the frame to the axle and spring assemblies.

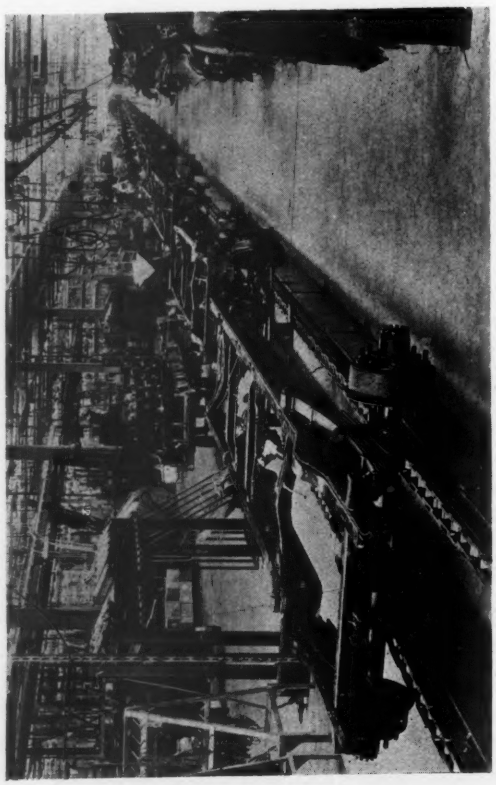


Fig. 14. The start of the main final assembly line.

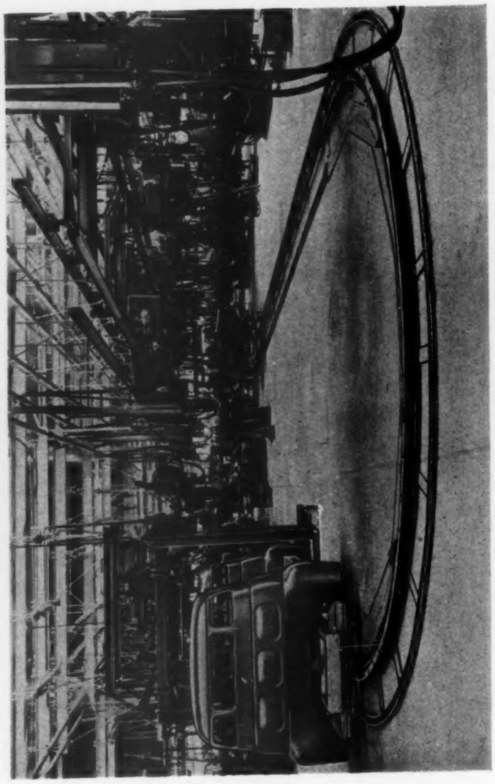


Fig. 15. An enclosed circuit welding conveyor.

Fig. 16. One of the conveyors carrying cabs to the trim lines.

Fig. 17. Vehicles approaching the end of the final assembly line.

of the differential.

A bank of sub-assemblies of back axle housings and tubes is located adjacent to the start of the assembly conveyor. A sub-assembly is transferred from the bank by electric hoist to a simple form of loading cradle which can be seen in Fig. 0. At the appropriate moment the loading device is moved forward by compressed air and the axle is picked up by a special twin hook carrier on the assembly conveyor. This type of carrier allows the axle assembly to be rotated about its horizontal axis to any desired position for easy working.

The flight-bar conveyor is 80ft. long, runs at 2ft. 4in. per minute and has 13 working stations. At the end of the conveyor the completed axle is dropped on to an unloading frame from which it is transferred by electric hoist to a mono-rail conveyor for passage through the paint spray booth and a drying oven.

Front axle assembly is carried out on a simple bench type conveyor with trolleys that run on channel irons. A jig for carrying the axle is mounted on each trolley. This conveyor is shown in Fig. 8. It is 50ft. long and runs at 2ft. 0in. per minute. Completed front axles are transferred to the same mono-rail conveyor as the back axles for passage through the paint spray booth and drying oven. Incidentally, hubs and drums are also assembled on an assembly conveyor. It is a slat type 44ft. long and runs at 3ft. 0in. per minute.

After the axles have been painted and dried, and while they are still suspended from the mono-rail the axle and spring assembly is carried out. These axles and spring assemblies are then transferred to carriers suspended from enclosed circuits of mono-rail. There is one circuit for back and one for front axles. This arrangement gives a small bank of axles conveniently situated for the next operation in the sequence, assembly of the chassis frame to the axles and springs.

Engine Assembly

Commercial vehicle engine assembly is carried out on an over-and-under type platen conveyor which has 101 platens in all. It is 250ft. long, runs at 2ft. 0in. per minute and has 49 working stations. It is shown in Fig. 9. Two types of engines are assembled on it. The roller conveyor from the cylinder block line finishes immediately adjacent to the start of the assembly conveyor. There is sufficient length between the end of the machining line and the end of the roller conveyor to hold a small bank of machined blocks. Banks of other components and sub-assemblies are held at convenient positions along the assembly conveyor.

The most interesting feature of this assembly conveyor is that provision is made for motoring the engine, see Figs. 10 and 11, while it is actually travelling along the conveyor. When the engine reaches a certain station in its progress along the line, a limit switch is automatically tripped. This starts a mechanism that causes an electric motor mounted on a carriage at right angles to the assembly line to move forward and lodge on the conveyor immediately behind the engine that is to be motored. The operator then connects the motor to the engine by means of a simple dog clutch arrangement and connects the oil feed pipe to the main engine oil gallery.

Motoring continues while the engine passes along ten stations on the conveyor. During this period the timing is checked and adjusted. When the end of the motoring section is reached, the motor and oil pump are uncoupled from the engine and is then automatically pushed clear of the assembly conveyor and returned to its rest position opposite the start of the motoring section. At the end of the conveyor line the engine is transferred to a carrier suspended from a mono-rail on which it is first carried through the paint spray booth and then transported to a nearby station for assembly into the chassis.

As one of the aims of the factory lay-out is the elimination of unnecessary transport, particularly of bulky articles, chassis frames are delivered direct from the supplier to a store on the opposite side of the building from the main stores area. From this store the frames are issued direct to an assembly conveyor which is shown in Fig. 12. This is of the double-strand raised-link type with cradles for carrying the frames. It is 138ft. long and runs at 7ft. per minute. During the frame's passage along the conveyor all the necessary attachments are riveted into place. Powerful and weighty squeeze riveters are used, but they are so nicely counterpoised on special balancers of Vauxhall design that there is little operational fatigue in the course of a normal day's working.

The chassis frame preparation

finishes in a position adjacent to both the storage banks of axle and spring assemblies and the main chassis assembly line. To begin the chassis assembly axle and spring assemblies are mounted as shown in Fig. 13 and the chassis frame is then bolted to them. This complete assembly is then mounted on the main chassis assembly conveyor, shown in Fig. 14. This is a raised-link double-strand roller conveyor 726ft. long. It runs at 6ft. per minute and has 52 working stations. For the last 300ft. of the commercial vehicle line the vehicles pass over an illuminated pit, lined with white tiles, to facilitate under-chassis operations.

Cab Assembly

Four types of vehicles pass down the main commercial vehicle assembly line. They are referred to as K, M, O and S types. For some, only the completed chassis is required; others have the front end of the cab unit fitted to the chassis; others have a complete cab unit; and a relatively small proportion of the total output consists of complete vehicles with standard Vauxhall bodies. Cab and front end units for K.M. and O types are identical and can be produced on the same assembly lines. Those for S type vehicles are different and are produced on separate assembly lines.

Assembly of cabs for K.M. and O type vehicles is carried out on a double-strand raised-link roller floor conveyor. It is 117ft. long and runs at 16in. per minute. Front end assemblies for these types are produced on a similar type of conveyor 225ft. long. Two conveyors are used in the production of S type cabs. One is a double-strand raised-link roller floor conveyor. The other, a welding conveyor is a dragging floor conveyor of 250ft. closed circuit. On this conveyor, each cab is mounted on a bogey and carried through a number of welding jigs. This conveyor is shown in Fig. 15.

After assembly, all cabs and front end units are mechanically conveyed through the cleaning and painting plant from which they pass either to the cab trim line or to the front end trim line. A conveyor carrying cars to a trim line is shown in Fig. 16. Each of these lines is served by a double-strand raised-link roller floor conveyor. That for cab trim is 195ft. long and that for front end trim 92ft. long. Both run at 2ft. 2in. per minute. Each of these conveyors finishes in a position convenient to the appropriate station on the main commercial vehicle assembly line. Each vehicle leaves the final assembly line ready to be driven away after inspection. Vehicles approaching the end of the line are shown in Fig. 17.

This factory sets a new standard for material handling in the manufacture of commercial vehicles. That all the manufacturing problems are carried out in a single building is a great advantage, but nevertheless many difficult problems had to be solved. That they have been solved so successfully is in great measure due to close liaison between the lay-out, tooling and materials handling divisions at every stage of the project. As a result there has been complete integration of the work of these three divisions. This has produced an installation of optimum efficiency as regards both plant and equipment and economy of man-power. It has also made it possible to ensure a continuous flow of work with relatively small contingency stocks, and consequently there is in relation to output only small investment in work in progress.

BRITISH STANDARDS

A NEW, and considerably enlarged edition of the handbook of British Standards for the Automobile Industry, B.S. handbook No. 8: 1950, has recently been issued. This new edition contains 514 pages. It is hoped that the inclusion of much additional material, together with a re-arrangement of the sections and an alphabetical index, will increase the value of the handbook as a work of reference.

The number of standards of interest to the automobile industry is so great that it is not possible to reproduce them all in full in one volume. Nevertheless, an endeavour has been made to compress into a book of reasonable dimensions sufficient of the current British Standards, in extract, precis or list form, together with full details of S.M.M. & T. Standards and extracts from American standards in common use in this country. It is hoped that this will enable designers and engineers to maintain an up-to-date knowledge of the standards which are of direct application to their work.

More than 300 standards are covered. They include American S.A.E. standards, horse-power correction charts, ferrous and non-ferrous metals, bars and forgings, castings, sheet, strip, tubes and wire. Radio interference suppression is dealt with comprehensively. This handbook should prove invaluable to those associated with the automobile and associated industries. The price is 21/-, postage free.

Copies may be obtained from the British Standards Institution, Sales Department, 24, Victoria St., London, S.W.1.

Voltage Reference Tube

MULLARD ELECTRONIC PRODUCTS, Ltd., Century House, Shaftesbury Avenue, London, W.C.2, have recently introduced a miniature voltage reference tube to meet the demand for a compact and stable source of voltage reference for direct use in electronic circuits. Working in a constant current circuit, the new 85A2 tube provides a voltage source having a short term stability of better than 0.1 per cent and a long term stability of better than 0.2 per cent. It is stated that this high stability is maintained even under intermittent switching conditions. (1921)

Rubber Wall Plugs

A NEW series of electrical wall plugs and sockets are being marketed by W. W. Haffenden, Ltd., Richborough Rubber Works, Sandwich, Kent, designed particularly to withstand the hardest of usage. The all-rubber casings are of a special type, and the flexible pin mounting is designed to provide a measure of flexibility and to give resistance to hard wear. In addition to the standard rubber colour, they are made in brown, black and white, and are marketed in 2, 5 and 15 amp capacities to the standard pin dimensions, and under the trade name "Duraplug".

Electroplating

ALL engineers who are concerned with any form of electroplating, and that includes many in the automobile industry, will find much information of interest and value in a booklet *Electroplating*, recently published by W. Canning and Co., Ltd. It is in effect an instruction book for the use of "Zonax" plating salts and cleaners and is not concerned with the complex chemistry of the various processes. Cleaning and pre-treatment, and all the common plating processes are dealt with in a concise but adequate manner so far as the actual processing is concerned and this publication should be studied by all who are responsible for plating operations. Copies may be obtained by application to W. Canning and Co., Ltd., Great Hampton St., Birmingham, 18. (1919)

Propeller Shafts

ON page 324 of *Automobile Engineer* for September/October 1950, reference is made to the large size Hardy Spicer joint with a low gear torque capacity of 52,000 in. lb. This figure should be 144,000 in. lb.

BODY PRODUCTION

A Survey of the Methods Employed by Park Royal Vehicles Ltd.

THE production of bodies for commercial passenger vehicles raises certain problems that differ in both degree and kind from those generally encountered in the automobile industry. This is particularly true of those organizations concerned solely with body building. Every such organization must in the first place, be prepared to produce bodies to suit many different types of chassis. In addition, they must be prepared to conform to specifications laid down by the customer, and there may be appreciable differences in design for bodies that are to be mounted on similar chassis. This multiplicity of types inevitably leads to a considerable degree of small quantity production. In fact, one-off designs are not uncommon, but the general run of orders call for quantities between 20 and 50. A demand for 1,000 similar bodies is a rare occurrence.

Despite the many difficulties that must be overcome to ensure complete interchangeability of parts in small quantity production at competitive prices, Park Royal Vehicles Ltd. decided to develop methods that would give complete interchangeability of parts for any specific design of vehicle. Necessarily, the first step was to establish tolerances. These, incidentally, are remarkably close for the class of work. A second point was to effect standardization of basic components so far as possible, in order that the total quantities involved would be such as to warrant relatively large tooling costs.

Fig. 1. L.T.E. bus with coachwork by Park Royal Vehicles Ltd.

An interesting example of standardization in the products of competitive companies arises in the manufacture of double-deck bus bodies for London Transport Executive. In the preparation of the latest design, designers from L.T.E., Park Royal Vehicles Ltd. and Weymann Motor Bodies Ltd. worked together with the result that there is complete standardization as between a Park Royal body and a Weymann body. As a further measure to effect production economies, the two manufacturing companies have a working arrangement whereby one takes responsibility for producing the combined requirements for certain parts for L.T.E. bodies while the other company produces the combined requirements for other parts. This obviates the duplication of expensive tooling and also allows the production runs to be carried out on economic quantities.

Despite the measures taken to allow production in fairly large quantities, there are still many parts that must be produced in small quantities. For

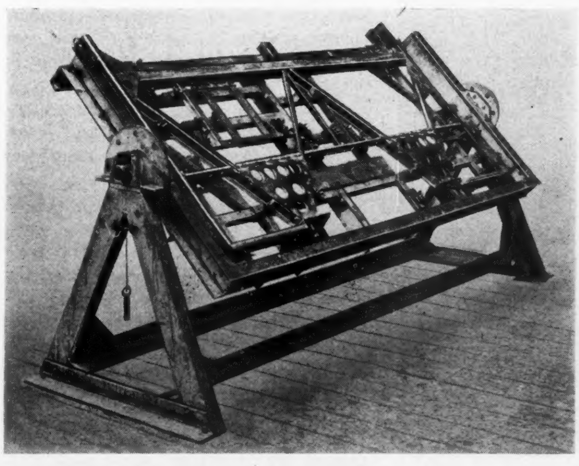


Fig. 2. Welding jig for front bulkhead main structure.

Fig. 3. Completed front bulkhead for L.T.E. body.

Fig. 4. The underframe, partly assembled, in the first main jig.

these, jig and fixture costs must be kept low, otherwise amortisation charges would be disproportionately high. Nevertheless, even when only a small number of similar bodies has to be produced, the jigging is so efficient that all the parts are interchangeable. This is a great advantage to the user, since if any part of the structure should be damaged, Park Royal Vehicles Ltd., can supply a replacement that is ready for immediate fitting into position.

This measure of producing basic components to carefully established tolerances is important in effecting production economies since it allows the actual body building to be a true assembly operation that eliminates the need for fitting and can be carried out in fixtures. Labour charges represent an appreciable proportion of final costs and the fact that the many units comprising a body are merely assembled means that relatively unskilled labour can be used and the actual assembly time is reduced. Furthermore, the process timing is much closer than would be possible if the assembly entailed any degree of fitting. This is quite an important point. It ensures synchronisation between lower and upper saloon lines for double-deck bodies. In addition, if the scheduled timing were not maintained, the question of chassis storing could become difficult.

The production of the basic components is carried out in the appropriate one of several different departments. These include :—

(a) The sawmill where all the timber parts are produced accurately to size.

(b) The press shop for the production of such parts as brackets.

(c) The sheet metal department for panel beating and the production of metal cappings.

(d) Interior finishing department.

(e) Protective treatment department.

It is worth noting that the Company lay great stress on protective treatment for both timber and metal used in body structures, even for parts that are not exposed. They estimate that the efficiency of the treatment increases the vehicle life threefold. Metal protective treatment is carried out in a well equipped department. The plant includes equipment for trichlorethylene de-greasing, de-rusting in a Jenolite tank, Bonderizing, enamelling either by spraying or dipping according to which is the better for the specific article, and an infra-red stoving oven.

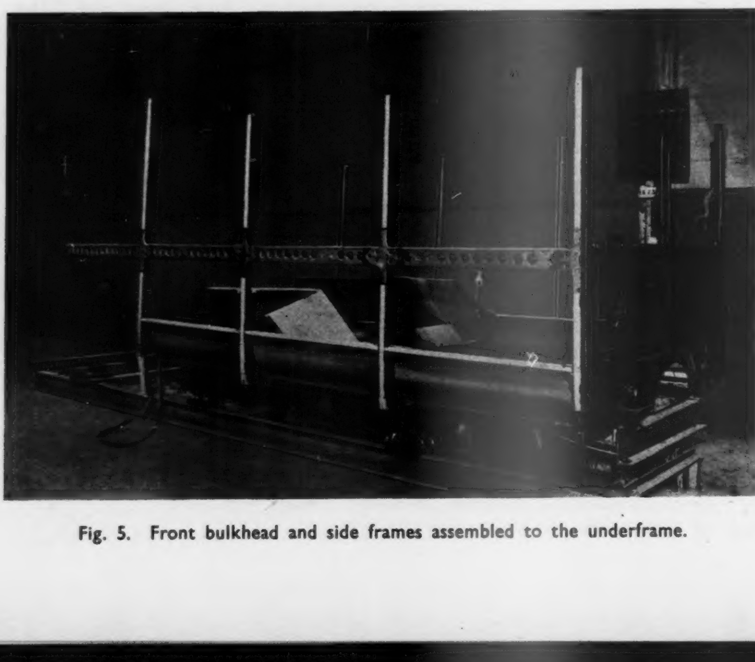


Fig. 5. Front bulkhead and side frames assembled to the underframe.

Assembly Sections

There are four assembly sections; one for metal frame bodies that are usually standard Park Royal design; a second for metal frame bodies for L.P.T.E.; a third for composite bodies; and the fourth for rail cars. Each section is laid out to give progressive flow production, though not necessarily completely straight line. The assembly methods may best be illustrated by consideration of the section for building double-deck bodies for L.T.E. since this section calls for synchronisation between the assembly line for the lower saloon and the line for the upper saloon. A finished vehicle of this type is shown in Fig. 1.

There are three parallel lines in this section. On the first line the lower saloon is built and then mounted to the chassis. The upper saloon is assembled on the second line and it is assembled to the lower saloon and chassis on the third line. The direction of flow for the third line is opposite to that for the other two. Even after the dimensional tolerances to give interchangeability had been established careful planning was necessary to give an even flow of production. It is not impossible to carry contingency stocks of parts and small sub-assemblies, but considerations of space alone, apart from the economics of investment in work in progress, preclude any possibility of carrying stocks of the main units.

To obtain balanced assembly from the various unit assembly fixtures has entailed careful process planning. Here it may be mentioned that the system of payment employed does help to maintain an even flow. All the

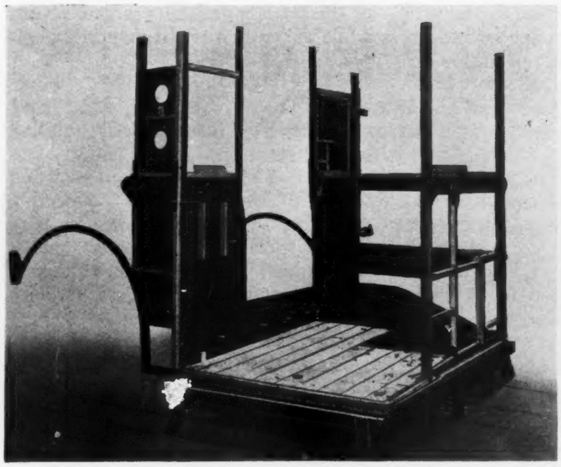


Fig. 6. Rear platform and partition unit ready for transfer to the lower saloon final assembly fixture.

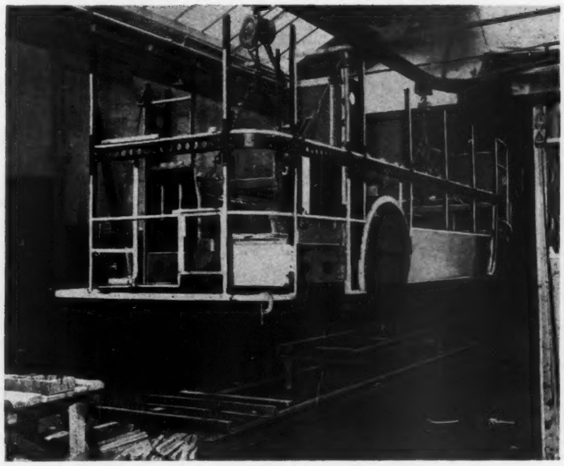


Fig. 7. The end of the lower saloon assembly line, with an assembly ready for mounting on the chassis.

persons employed on the assembly of one particular type of body share in a common bonus. Because of this, if for any reason the production of some particular unit falls behind schedule and is holding up output, there is no difficulty in switching labour to overcome the trouble.

It is not intended to deal in complete detail with all the processes involved in building a double-deck body for L.T.E., but rather to discuss the general process sequence. As with most other Park Royal vehicles, bolted and riveted construction is used for all the stressed members of the structure other than the front bulkhead. It is considered that this type of construction gives greater flexibility to withstand the stresses that will be encountered in service. It also simplifies repairs if any member is damaged in service.

Although most Park Royal bodies are of bolted and riveted construction, there are applications for which welded construction is preferable, and the factory is fully equipped for carrying out all the necessary forms of welding. In welding important structural members full use is made of welding jigs to ensure uniformity of product. For example, the front bulkhead main frames for L.T.E. bodies are produced in the jig illustrated in Fig. 2. A number of sub-assemblies are previously jig welded and are then arc welded into a complete assembly, Fig. 3, in the jig shown. To complete the bulkhead, a perforated plate is machine spot welded to the structure.

The assembly of the lower saloon is effected in three main fixtures. Other fixtures for sub-assemblies are located adjacent to the main fixtures. In the first main fixture, Fig. 4, the underframe is assembled. After this assembly is completed it is transferred to the second fixture, see Fig. 5, where the front bulkhead, side frames, rear partition and platform unit and the wheelboxes are assembled to it. These various parts reach the fixture as preassembled units. For example, the rear platform and entrance partition riser panel unit is assembled in the fixture shown in Fig. 6. In the same fixture, the timber for the rear platform floor is laid and then the rear end framing and the entrance partition and the wheel arches are fitted, and the platform floor is laid. Timber inserts for attaching exterior panels and the battery crate framing are also fitted.

From the second fixture the partbuilt lower saloon is transferred to a third fixture, see Fig. 7, in which the flooring is laid, the driver's cab unit is fitted, as also are a portion of the exterior panels. The floor is also covered with cork tiles and linoleum and the wearing slats are laid. At this stage, the underside of the assembly is sprayed with aluminium paint and the lower saloon is then mounted to the chassis. The rate of output from the first and second fixtures is sufficient to warrant the use of two final fixtures.

Whilst the lower saloon is being produced on one line, work on the upper saloon proceeds on a parallel but much longer assembly line. On this line there are seven main stations. At No. 1 station, see Fig. 8, the intermediate roof is laid and the roof supporting members are fitted. At this stage the two side frames are

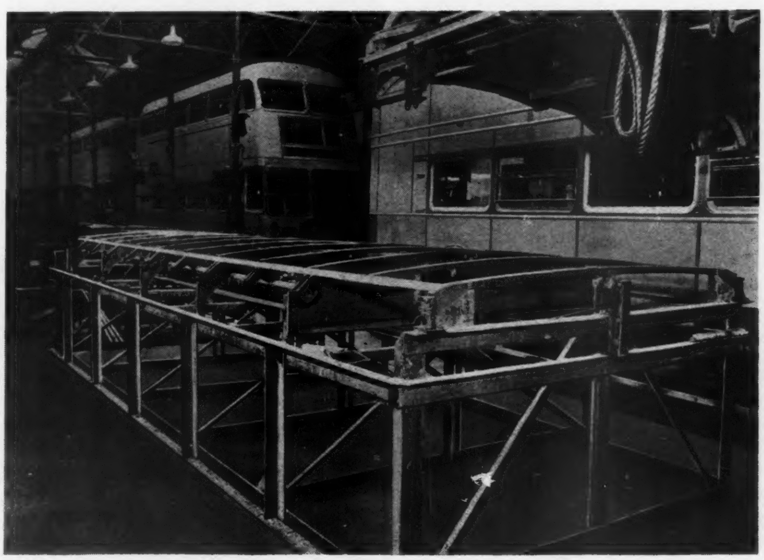


Fig. 8. Assembling the intermediate roof at the first station on the upper saloon assembly line.

fitted, the pre-assembled rear unit is fitted in position and finally the Jicwood roof is fitted.

This sub-assembly is then moved forward to No. 2 station where the pre-assembled timber framed front end is fitted in position. The necessary wiring is installed at No. 3 station. At No. 4 station the front and rear roof domes are fitted and the floor cove panels are fitted in position. The exterior panels are fitted and the floor covering and wearing slats are laid at No. 5 station, while the window pane and windows are fitted and the exterior panels are screwed and moulded at No. 6 station. At the seventh station the mouldings are fitted and the upper saloon is ready for transfer to the lower saloon and chassis assembly on the third line. Because of the accuracy of the basic components and of the jigged assemblies, the upper saloon has merely to be dropped into position on the lower saloon and bolted in place. Fitting is completely eliminated.

It is not intended to follow in detail the work done on the final assembly line, but one of the earliest operations is the assembly into position of the staircase which is pre-assembled in a simple form of jig. When the work on this line is completed, the body is practically finished, except for interior furnishing. From the end of this line the vehicle goes to a paint spray booth to be given a grey primer coat and it then undergoes a pressure water test for 20 minutes.

Inspection naturally plays an important part in maintaining the high standard specified for all Park Royal vehicles. In addition to a complete final inspection at the end of the final assembly line, there is a well-planned system of patrol inspection to ensure that the basic components conform to specification and there is also regular patrol inspection on each of the three assembly lines.

After the pressure water test, the body is again given a thorough inspection and then goes to the brush paint department where in addition to the previously applied grey primer it is given one flash undercoat, two coats of enamel, one coat of hard drying varnish and a final coat of finishing varnish which is applied in an air-conditioned chamber. All these coats are applied by brushing. The trim and upholstery departments are housed in the same building as the paint department, and practically the whole of the interior finishing is carried out while the painting is being carried out.

Overseas Liason

Park Royal Vehicles Ltd. have associations with other body building organizations both in this country and abroad. These are supplied with full technical information in connection with the building of bodies to Park Royal specifications. It is almost unnecessary to say that the Company enters into this arrangement with another organization only after very full investigation has shown that the Park Royal standard will be maintained.

The arrangement operates in two ways. In some cases Park Royal supply working drawings and full technical information concerning the necessary jigs and fixtures and the associated company produces the basic components. In others, Park Royal Vehicles Ltd., also supply the basic components and the associated company is responsible only for the assembly. This liaison is already operating with organisations in several different companies and is to be extended. It is a valuable factor in helping the export of British commercial vehicle chassis.

FISHER AND LUDLOW

A MOST excellent custom amongst our older engineering firms is the publication of brief histories of their genesis and growth. This practice, which has everything to commend it, has resulted in the production of some outstanding booklets. Not only are these of interest to those engaged in the particular side of the industry concerned, but the general publicity value must be considerable, particularly abroad. Firms in other countries having business associations with Britain, and also potential customers abroad, must inevitably feel more closely linked by these individual records.

Any such history that covers a period of 100 years or more is by no means common, and the latest example to hand, issued by Messrs. Fisher and Ludlow, Ltd., Birmingham, falls into this category. Most unfortunately the Company's early records were all destroyed in the "blitz", so that much of the early matter had to be compiled from the recollections of old employees and pensioners. This handicap has, however, detracted in no way from the quality and interest of the booklet now published, which is well illustrated and covers in brief the story of the firm's inception, growth and present day activities.

As is so often the case, the now mighty firm of Fisher and Ludlow began in a very small way indeed. The first tangible record dates back to 1849 and relates to a small shop making kettle spouts, ladles and other odd presswork. Accounts of these early days have always a fascination inseparable from intimate family records, and it seems almost incredible that even in 100 years a growth such as Fisher and Ludlow evidence, should have been possible. The tale of expansion, wars, and development, is well and interestingly told, the many fine colour illustrations and reproductions of contemporary photographs providing a vivid record of achievement. One of the most striking facts that emerges is the extent to which the Fisher and Ludlow factories suffered in World War II. In December, 1940, 14 of the Company's factories were put out of action.

Whilst most engineers associate Fisher and Ludlow with motor vehicle frames and bodywork, the Company's output includes a variety of products based upon steel presswork and fabrication. All kinds of mechanical handling equipment is produced, also washing machines, vitreous enamel ware, miscellaneous articles in stainless steel, and so on. This centenary souvenir is excellently produced and congratulations must go to the designers, S. D. Toon and Associates, Ltd., of Birmingham, with congratulations also to Messrs. Fisher and Ludlow, from whom a copy of the booklet is obtainable on application.

New Road Map

A NEW type map has recently been published by Daimler Hire. The result of some two years' work, the "Roadfinder" is a simple-to-read map based exclusively on the numbered road system. Although designed primarily for overseas visitors, it should also prove of value to British motorists to whom the numbered road system has never been officially explained since it was begun in 1914. The Highway Code, for example, does not mention it and on many maps, road numbers can easily be confused with mileage figures. A pocket-sized production, measuring 7¾in. × 4½in., it is 28in. × 22½in. open. Particularly legible, it can be used in a car without arm-stretching or eye-strain.

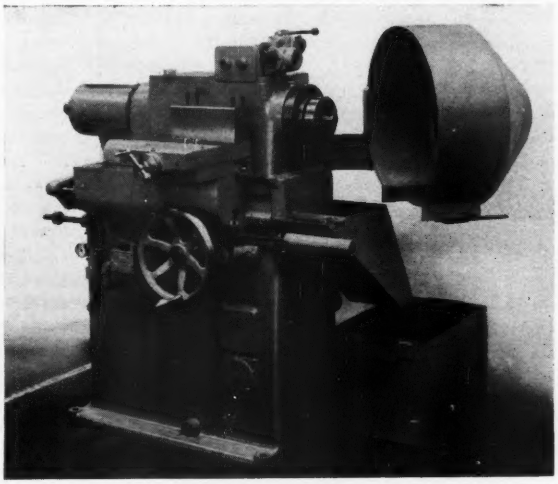
M.I.R.A. Proving Ground

IN the leading article headed "High Speed Testing" in the December 1950 issue of *Automobile Engineer*, reference is made to the M.I.R.A. proving ground at Silverstone. This is, of course, incorrect, since the M.I.R.A. proving ground is at Lindley.

NEW PLANT AND TOOLS

Recent Developments in Production and Factory Equipment

A NEW machine, the Edgwick stub lathe, has been developed by Alfred Herbert, Ltd., Coventry, for turning or boring short, large diameter work. It is illustrated in Fig. 1. Primarily the machine has been designed for boring the brake - shoe track in brake drums for motor vehicles, but it is also suitable for other work such as pulleys, circular cover plates and electric motor end-shields, where the machining must be true with a previously machined hole.

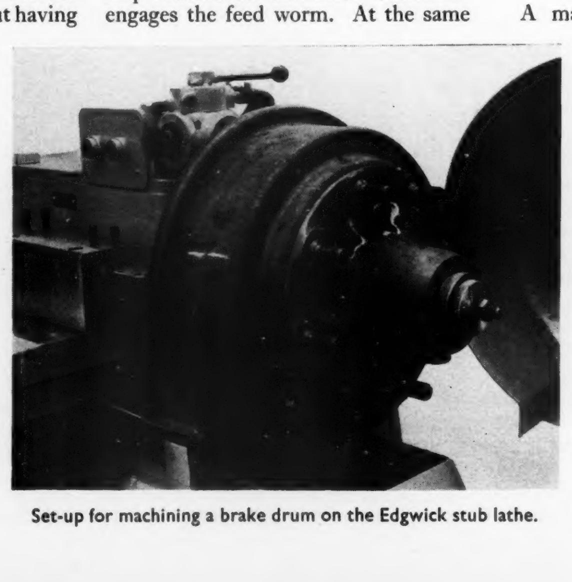


Edgwick stub lathe.

This is essentially a machine to give high production rates and the design incorporates several interesting features. They include: cam-controlled tool slide for retracting the tool at the completion of the cut, a completely automatic work cycle after the work is loaded, air - operated chucking, air-operated tool slide return and a worm driven work spindle. Another important feature of the design is the open end which greatly facilitates the loading of heavy work into the machine.

Some brake drums for large motor trucks are especially heavy since they are first assembled on the wheel hub to ensure that the track is machined truly concentric with the axle bearings. With this design the operator can lift the work into the fixture without having to lean over the lathe bed or any other part of the machine. Even if a hoist is used for lifting the work, loading will be facilitated by the fact that the operator faces the chuck.

A brake drum mounted ready for machining is illustrated in Fig. 2. The brake drum proper has been assembled on its wheel hub so that location can be taken from the wheel hub bearing outer rings. One of the roller bearing taper cups locates on the conical portion of the fixture, while another conical plug is inserted in the hub and registers on a ground parallel portion of the work fixture. The work is clamped endwise by an air-operated draw rod and a C-washer. Additional support is given to the work by a flexible rubber ring on the fixture near the periphery. This ring also effectively damps any tendency to vibration that may be inherent in the work.



Set-up for machining a brake drum on the Edgwick stub lathe.

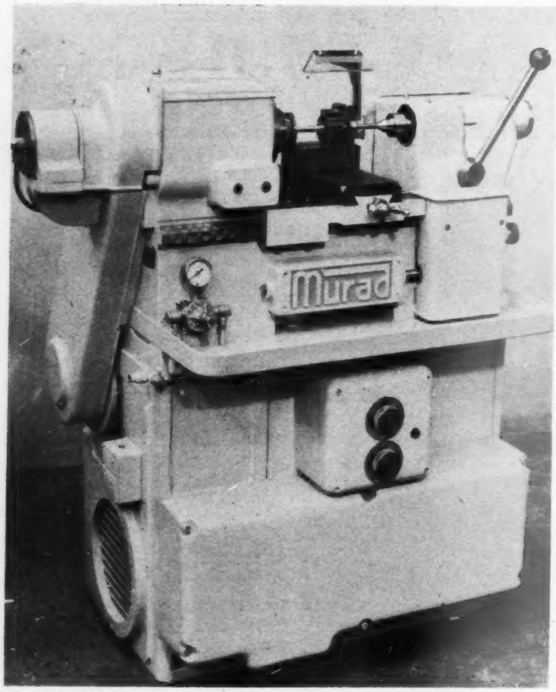
When the work has been loaded and clamped, the operator starts the automatic cycle by moving the ball-ended lever to the right of the handwheel. This engages the feed worm which is driven by belt from the work spindle through pick-off gears. The saddle travels to the right until an adjustable stop contacts another lever which disengages the feed worm. At the same instant the top slide carrying the tool retracts so that the tool is completely clear of the machined track as the saddle returns to the starting point.

Saddle return is effected by air pressure. It is controlled automatically by (1) opening a valve at the front of the machine by means of a stop set to operate just before the saddle completes its machining stroke and (2) the dropping of the feed worm at the back of the machine which opens a valve and admits air to the return cylinder. Another stop closes the first valve at the end of the return stroke. This opens the air cylinder to atmosphere so that the saddle can be moved by hand without working against air pressure. During the return of the saddle a pendulum stop depresses an electric switch which stops the main motor. The machine is then ready for unloading and reloading. The principal dimensions are:—

Minimum turned diameter ..	8¾in.
Minimum bored diameter	
with standard toolholder ..	13¼in.
with special toolholder ..	9in.
Maximum length turned or bored	6in.
Maximum tool slide stroke ..	7in.

Murad Lathe

A machine specially designed by Murad Developments Ltd. Stocklake, Aylesbury, Bucks., for turning the commutators for electric motors manufactured by Hoover, Ltd., is shown in Fig. 3. It gives a completely automatic work cycle. The left hand end of the rotor shaft is inserted in a collet equipped with a back stop. The lever of the tailstock is then moved forward to bring the tailstock centre into contact with the work. Further movement of the lever beyond this point actuates a compressed air control that closes the collet. This completes the loading.



Special Murad lathe for turning small commutators.

The operator then presses the start button mounted on the headstock. This sets the spindle in motion. The tool then approaches the work at rapid traverse and slows down to cutting feed at the appropriate point. As soon as the tool is clear of the work, the spindle stops and the tool withdraws under rapid return to the starting position. Then the lever controlling the tailstock centre is moved back. This first opens the collet, and further movement withdraws the tailstock centre from the work, ready for unloading and reloading.

Two motors are employed. One for the drive to the main spindle, and one for the drive to the feed mechanism. They are controlled by oil-immersed contactor switchgear housed in the lower of the box guards. The upper guard contains the isolating switch and a switch which enables the saddle to be inched in either direction along the bed. Both motors are equipped with electric brakes to bring them to a full stop as required by the sequence of the slide movements.

The movement cycle on the tool slide is controlled by a cam driven by a train of pick-off gears from the feed motor. This allows variations to be made in the rapid approach and feed relationships as well as in the cycle of operations. Provision is made for adjusting the depth of cut. To facilitate accurate setting, a micrometer dial is provided. Fine adjustments along the axis of the bed can be made through the auxiliary slide mounted on the main cross-slide. Provision is also made for adjusting the height of the tool in the tool post.

The main spindle design of this machine is based on the spindle design of the Murad $\frac{3}{4}$in. capstan lathe. Automatic lubrication is provided for the spindle bearings. Lubrication of the various sliding components in the tailstock assembly is effected through oil nipples. A swinging perspex guard which automatically moves into position at the start of the cycle and withdraws at the end, protects the operator from flying chips while still affording a complete view of the tool in operation.

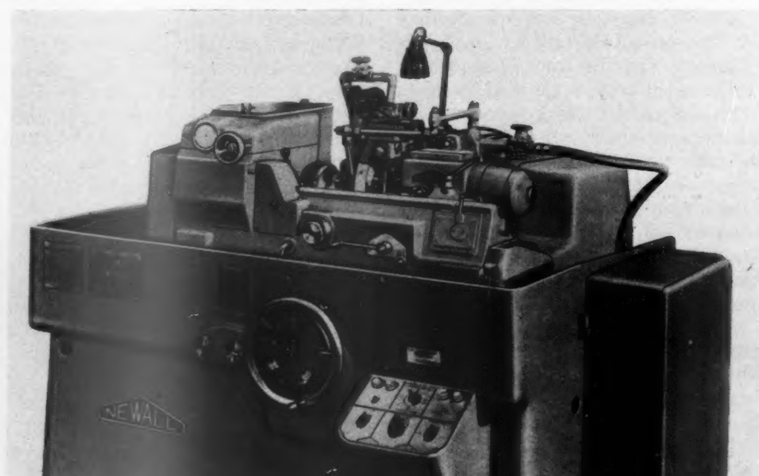
Newall Thread Grinder

Newall Engineering Company Ltd., Peterborough, have recently developed the thread grinding machine illustrated in Fig. 4. It is designated type NL. (Linder type). In addition to being suitable for thread grinding, the machine can be simply adapted for the production of regular or irregular profiles, either helical or annular. As a result, form-relieved milling cutters, circular form tools and other work can also be ground. The scope of the machine can be further increased by the use of a combined internal and hob grinding attachment with spindles to take wheels from $\frac{5}{8}$in. to 6in. diameter, and a surface grinding attachment with a $5\frac{1}{2}$in. long $\times$ 6in. wide capacity.

This machine is available in two sizes. One accommodates 32in. between centres with a grinding length of 20in. The corresponding dimensions for the other model are 16in. and 10in. Both will grind a diameter of 8in. over the full length capacity and a diameter of 10in. up to 4in. distance from the spindle nose.

Each size of machine is available in four types. Type A is designed specifically for the highest quality work, such as thread gauges, and cannot be fitted with a form relieving attachment. Type B is a universal toolroom machine and takes all the available attachments, while type C is specifically intended for producing high quality taps and milling cuttersl It has a maximum workhead speed of 60 r.p.m. The type D machine has workhead speeds ranging from 0.2 to 20 r.p.m. and is designed primarily for production work by the plunge cut method. The maximum wheel diameter that can be used for external grinding is 14in.

There is hand-operated in-feed for the wheelhead which moves on vee



Newall N.L. (Linder type) thread grinder.

and flat ways. The handwheel dial is calibrated to 0.00025in. on diameter. Power in-feed and fine hand in-fed are applied to the work by tilting the work table. On all machines other than type D the spindle is belt driven from a countershaft which is driven from a 2½/5 h.p. 2-speed motor. On the type D machine, a 7 h.p. single speed motor is used.

Plain, adjustable wheel spindle bearings of a special type are fitted. They allow the spindle to run with a very small clearance so that the temperature rise is only in the order of 10deg. C. Axial location is provided by a plain outboard thrust member located within a few inches of the wheel so that lateral displacement of the wheel due to expansion of the spindle through temperature rise is negligible. This thrust pad can also be used to displace the wheel laterally to permit the form to be dressed close to the edge for grinding up to a shoulder.

Various methods of wheel forming may be employed. The main alternatives are :—Newall pantograph diamond dressers with ratios of 15 : 1 and 4 : 1 for single or multi rib wheels; Linder type universal and profile dressers ; and a crushing device. The various alternative diamond dressers and crusher units are provided with micrometer adjustment. They are arranged to be mounted at the rear of the wheelhead. A microscope and lighting unit for the inspection of the wheel form can be fitted and a wide range of thread form graticules is available. To facilitate wheel forming, all the necessary electrical controls are duplicated at the back of the machine.

When the machine has been set up for a specific job, there is no need to move the wheelhead, since increments of feed, compensation for wheel wear and dressing, and withdrawal of the work from the wheel are all obtained by movement of a fine feed worm and table eccentric. The frictional forces opposing the rocking of the table about its supports are negligible. It is claimed that increments of feed as small as 0.00001in. can be obtained reliably by relatively unskilled operators. When the machine is used for form relieving, a suitable cam connects to the work spindle through a train of change gears selected to suit the number of flutes in the work. A similar principle is employed for plunge-cut thread grinding and annular profile grinding, although necessarily the cams are of different form.

For annular profile grinding, cylindrical grinding with a formed wheel, comparatively high work speeds are employed during a considerable number of work revolutions. An appropriate shaped cam controls the in-feed of the work. It is of such form that the feed is arrested for the last few revolutions of the work to give a dwell period. As the cam must make slightly less than one revolution while the work makes a number of revolutions, a differential gear unit is fitted inside the workhead. This allows the required ratio between the cam and the work spindle to be obtained.

Pitch compensation wheels can be supplied for grinding pitches slightly greater or less than standard, such as may be required for crushing rollers. They are used in combination with the standard pitch change wheels and will increase or decrease the pitch by an amount that can be selected from a wide range between 0.00008in. and 0.00437in. per inch. If extreme accuracy is required, it is often possible to choose a gear combination that will allow for the heating of the work that occurs during grinding.

The live centre workhead is fitted with a large diameter hardened steel hollow spindle, bored No. 4 Morse taper and running in adjustable plain bearings. Hardened and lapped flat thrust pads held in contact by spring pressure provide axial location and make adjustment for wear unnecessary. The spindle nose is enlarged to form a shallow taper spigot and flat face for the accurate location of work-holding fixtures.

A precision balanced ½ h.p. 1500 r.p.m. motor provides the drive to the workhead spindle. It is connected by vee belt to a steplessly-variable H-gear unit that has a 10 : 1 ratio. The output shaft of the H-gear unit drives the spindle through a pair of helical gears, two pairs of worms and worm-wheels and one of two spur gear trains. These spur gear trains give speeds in the ratio of 10 : 1. As a result the overall speed change ratio is 100 : 1.

On type A and B machines, the work speed can be varied between 0.3 and 30 r.p.m. The corresponding figures for the type C machines are 0.6 to 60 r.p.m., and for type D machines 0.2 to 20 r.p.m. The maximum return speed is limited by the highest available work speed, but a single-tooth clutch arrangement operated by a lever on the workhead allows the table to be wound back rapidly.

There are two centralised electrical control panels, one at the front and the other at the back of the machine. On each panel there is a main "stop" button, which also serves as an emergency stop for the whole machine. There are also three other push buttons which give respectively normal wheel speed for grinding and finish dressing, half wheel speed for dressing with form diamonds and a slow speed for crushing to form. In every case, when the appropriate button is pressed, the wheel spindle is flooded with lubricant for 5 to 10 seconds before the spindle starts to rotate.

CORRESPONDENCE

Correspondence on subjects of technical interest is invited. The name and address of the writer must be given, though not necessarily for publication. No responsibility is accepted by the Editor for the opinions of correspondents, and the right is reserved to omit any portion of a letter. If a reply by post be desired, a stamped addressed envelope should be enclosed.

CLUTCH THRUST BEARINGS

SIR,—We are responsible for the manufacture of the carbon clutch release bearings used in automobile clutches, and have read with interest your comments on the performance of this component, contained in the London Show Review of the *Automobile Engineer*, November 1950.

The picture you have given of the performance of the carbon clutch release bearings is not in line with recent technical development ; a new material has been developed in the shape of copper carbon, which is a combination of copper and carbon, and this is successfully meeting those points you have made against plain carbon release bearings.

We agree that the duty of the automobile clutch under modern traffic conditions is onerous, but our copper carbon material has been proved under the most stringent conditions, and operational life is several times that of plain carbon.

The very low rate of wear of the new material tends to balance the clutch lining wear, thus eliminating the need for frequent clutch adjustment.

This material has been adopted amongst others by two of the "Big Six" and has proved itself under export conditions where trouble was first met.

THE MORGAN CRUCIBLE COMPANY LTD.

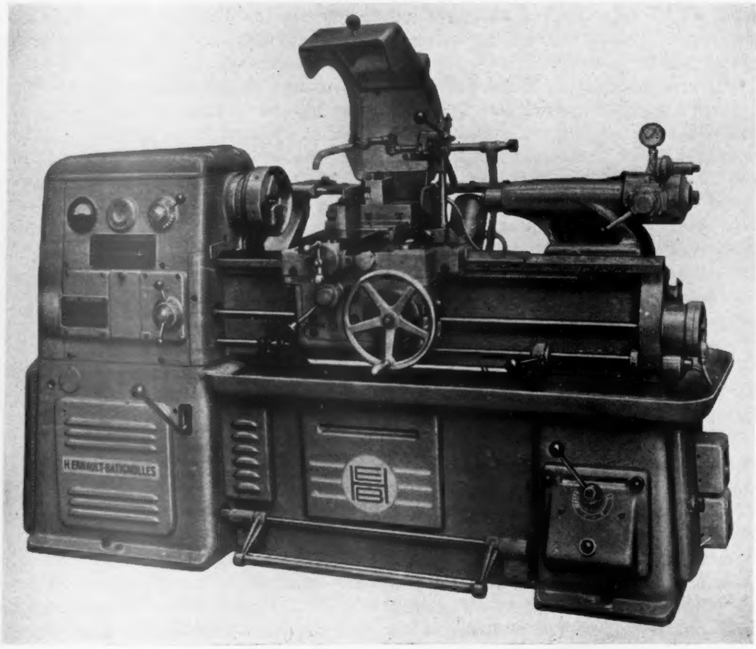
G. M. SLIGHT.

COPYING LATHES

French Machine Tools for the Rapid Production of Accurate Work

AN interesting range of copying lathes designed and manufactured by H. Ernault-Batignolles of Paris has recently been introduced to this country. These machines are widely used in the French automobile industry. They have been specifically designed to allow the optimum use to be made of the cutting properties of cemented carbide tools. There are two types, OP models for work of circular cross section and GT models for turning and boring components on which the cross section is not circular. These notes are concerned only with the OP models, one of which is shown in the accompanying illustrations.

Two sizes are available, one giving 13½in. swing over the bed and 5—$\frac{11}{16}$in. over the cross slide, while the corresponding dimensions for the other are 17½in. and 9—$\frac{11}{16}$in. The smaller machine is available in three lengths to accommodate 16in., 28in. or 40in. between centres, while there are two lengths of the larger machine to accommodate 28in. and 40in. between centres.



H.E.B. Hydraulic copying lathe

Since these machines are designed to take full advantage of the metal-removing properties of cemented carbide tools, they have a very wide range of spindle speeds with a maximum speed that is much higher than is general for machines of these sizes. The maximum spindle speed on OP copying lathes is 3600 r.p.m. This means that work of only ¾in. diameter can be machined at 700ft. per minute. With high spindle speeds the ill effects of vibration become much more marked and the elimination of vibration is of primary importance both as regards tool life and quality of finish on the work. Special attention has been paid to the elimination of vibration.

Bed and Base

As can be seen from Fig. 1 the design of the bed and base is such as to give great rigidity. The massive one piece base casting of box section ensures a solid seating for the bed even when standing on an uneven floor. Indeed, it is possible to operate the machine quite satisfactorily when it is merely resting on its levelling screws. Three large openings, normally closed in by cover plates, give access to the motor and gearbox. At the tailstock end there are two openings for access to the electrical control gear which is fixed to the hinged door and cover plate of these openings.

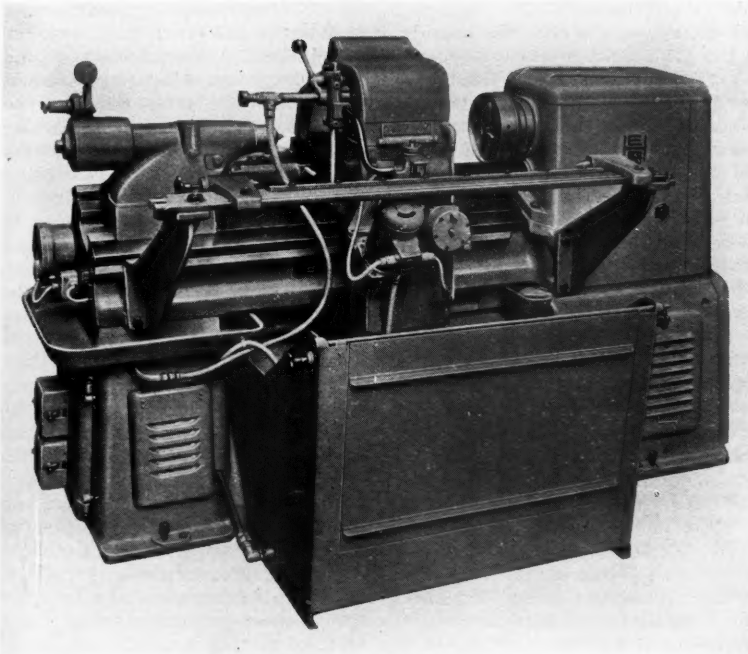
The deep bed of the sloping type is well cross-braced to withstand loads due to heavy cuts without bending or twisting. Resistance to deflection is further increased by its being rigidly fixed to the base casting. Telescopic guards cover and protect the front and rear slideways and the intervening space from swarf and cutting oil. As they slope in the same way as the bed, they prevent swarf from building up and guide it towards a large tray situated under the bed at the rear.

Spindle Drive

In designing this machine to have a maximum spindle speed of 3600 r.p.m., it was felt that an all-geared spindle drive would not be satisfactory. It was considered that no matter how accurately the gears were produced, there would still be small shocks as the gears meshed, particularly under the variable loading that occurs on a lathe. For this reason the motor and the gearbox are mounted in the base of the machine and the final drive to the spindle is by seven vee belts from the output shaft of the gearbox to a pulley directly coupled to the spindle. Therefore, except for spindle speeds below 500 r.p.m., there are no gears between the vee belts and the workpiece, and any minute vibrations set up in the gearbox at high speed are absorbed by the belts. Speeds below 500 r.p.m. are obtained by interposing a back gearing between the vee belt pulley and the spindle. These gears are hardened ground and shaved to a barrelled form, and at the relatively low spindle speeds with which they are used, any vibrations they may set up are insignificant.

A squirrel cage motor, wound for 3-phase, 50-cycles is used. It can be supplied for any voltage between 380 and 440. The no-load speed is 1500 r.p.m., and according to the nature of the work for which the machine is to be used the motor may be of 8, 12, 15 or 20 h.p. The motor is flange mounted to the gearbox and the assembly is mounted on rubber bushes, which together with the vee belts are the only connections between the power unit and the remainder of the machine. As these connections are all flexible they ensure that no vibration is transmitted to the tool or the work. The power unit is hinged at the rear to allow the vee belts to be tensioned.

Drive from the motor is taken through a multi-disc clutch. It allows the spindle to be started rapidly or



Rear view of H.E.B. copying lathe.

gradually. Clutch engagement is by means of a lever. Movement of this lever in the opposite direction engages a second multi-disc clutch that is used as a powerful brake that will bring the spindle to rest in about two seconds from the highest speeds. This brake can also be engaged by means of a treadle at the front of the machine.

Pick-off gears are used for speed changes. They have been adopted because H.E.B. consider that for this type of machine they have the following advantages over a lever-operated gearbox: (1) Pick-off gears give greater efficiency as the number of gears to be driven is smaller. This is of major importance at high speeds. For example, rotation of the spindle without cutting at 3000 r.p.m. through a lever-operated gearbox absorbs about 9 h.p. Because of the efficient gear train that is employed, the power required to turn the spindle of the H.E.B. copying lathe has been reduced to 4 h.p.

(2) Carbide tools are expensive and the cost of regrinding is also appreciable. Hence it is essential that tool life between regrinds should be as long as possible. Experiments show positively that tool life decreases rapidly when the cutting speed deviates either above or below an optimum speed that depends on the carbide that is being used and the material being machined. It is important, especially for roughing cuts demanding heavy power, that the gearbox should give a wide range of speeds in small steps. On the H.E.B. copying lathe there are 20 spindle speeds from 50 to 3600 r.p.m., each speed normally being 1.25 times the preceding speed. A lever operated box with such a range would be far more complicated.

(3) A copying lathe is generally used for machining batches of components, although the batches may consist of only half-a-dozen pieces. Furthermore, it is not equipped for screw cutting and there is not the necessity for changing speed as often as on a centre lathe. Therefore it is no great disadvantage that with pick-off gears speed changing takes a minute or two longer than with a lever-operated box. In order to change the pick-off gears, it is only necessary to undo a knurled screw holding the inspection door in position. This door locates the pick-off gears endwise and it is an easy matter to slide two gears off and replace them by two others. Neither spanners nor tools of any kind are required.

Headstock

An important point in the headstock design is that the vee belt pulley is concentric with, but completely independent of the spindle. It is mounted in its own ball bearings. This ensures that the vee belt drive does not cause any bending load on the spindle. The pulley drives the spindle either directly through a dog clutch or, at speeds below 500 r.p.m., through a double reduction gear with a ratio of 9 : 1. This gearing is engaged by means of a conveniently situated lever. The gear wheels are of specially treated alloy steel with the teeth ground and shaved to a special profile. When the dog clutch is engaged, both sets of gears are completely out of mesh in order to eliminate the danger of setting-up minor vibrations.

Considerable research has been carried out to determine the most suitable form of spindle bearings. At the front end the spindle is mounted in a special double taper roller bearing, assembled without any pre-load. This type was adopted because experience showed that with a pre-loaded bearing considerable heating occurred at speeds over 3000 r.p.m. In fact, there is slight play when these bearings are cold. At the rear there is a single taper roller bearing. It is spring loaded to take up the initial play in the front bearings and to allow for the longitudinal expansion of the spindle that is bound to occur as it warms up the normal operating temperature.

A tough alloy steel is used for the spindle which has a chuck mounting of the short overhang type. It is bored $1\frac{7}{16}$in. diameter and ground to a No. 5 Morse taper. Both the chuck mounting and the internal taper are case-hardened and tempered to a hardness of C62 Rockwell. At the rear of the spindle there is a vee belt pulley for driving the feed mechanism input shaft through two vee belts.

A simple gear system is used for driving the feed shaft, and feed changes are obtained by pick-off gears similar to those for the spindle drive. These gears are located endwise by a small hinged cover plate on the front of the machine. The cover plate is secured by one knurled screw, and to change the feed rate it is only necessary to undo the cover, push the gears off their respective shafts and replace them by another pair.

In addition to change in feed rates through a change of pick-off gears, it is also possible to effect an instantaneous feed reduction in the ratio 3.5 : 1 by movement of a lever. This can be done while a cut is being taken at spindle speeds as high as 2000 r.p.m. The ability to alter the feed rate instantaneously while the cut is on, is of great value where a fine finish is necessary over a small length of the work, but a coarser finish may be satisfactory on the rest of the length. In conjunction with six pairs of gears, this arrangement gives 22 different feeds from 0.008in. to 0.0354in. longitudinally. Transverse feeds range from 0.0004in. to 0.0177in. For special purposes, coarser or finer feeds may be readily obtained by using different vee belt pulleys.

Output from the gearbox is taken through a cone clutch. This is normally held in engagement by a strong spring, but can be disconnected electrically by means of a solenoid and a second spring at the remote end of the feed shaft. The solenoid is normally energised, but when the copying tracer contacts a shoulder on the template, the circuit is broken, thus releasing the second spring and causing the clutch to slip while the tracer feeds out to clear the shoulder. This arrangement is extremely sensitive and will maintain distances between shoulders to within 0.0015in. at feeds up to 16in. per minute and within 0.002in. up to 27in. per minute.

The solenoid circuit is also broken when the carriage contacts one of seven adjustable stops on a bar below the feed shaft. These stops are extremely easily set and are more accurate than mechanically operated stops. They operate equally well whether the feed is towards or away from the headstock. The bar and stops may be rotated by means of a handle that can be moved along the bar to any convenient position. As soon as the handle is rotated to clear the stop, the feed is automatically resumed. The cone clutch also acts as a safety device. It is set to transmit the necessary power to the feed shaft, but if this loading be exceeded, the clutch will slip and prevent any damage to the mechanism.

The Saddle

On a copying lathe the saddle is one of the most important parts, since it incorporates the copying mechanism. On H.E.B. OP copying lathes the saddle is designed as an integral unit and is particularly clean and simple. All oilways are drilled in the saddle block and are as short as possible. This eliminates any necessity for flexible pipes, which are not only a possible source of inaccuracy but also often have a short life.

A major problem in the design of a copying lathe is to provide mechanism to allow the cutting tool to feed out quickly in relation to the longitudinal feed of the carriage in order to produce square shoulders or tapers of more than about 90 deg. included angle. The most commonly used method of overcoming this difficulty is to fit the copying mechanism and tool to a slide attached to the saddle and inclined at an angle of 45 or 60 deg. to the axis of the machine. With such an arrangement right angle shoulders are machined by the differential action of the longitudinal feed of the carriage and the inclined feed of the tool. Apart from the complications that this type of design may involve in the connections between the tracer and the cutting tool, H.E.B. also consider it has the following disadvantages :—

(1) When cemented carbide tipped tools are used, the elimination of vibration is of primary importance if maximum tool life and machining accuracy are to be obtained. One source of biration is the sliding surfaces of the saddle which must necessarily have some clearance between them. The smaller the number of such sliding surfaces the less the vibration and inaccuracy from this source. Additional members sliding at 45 or 60 deg. are therefore to be deprecated. In this connection, the H.E.B. saddle is very simple. There are only two sliding motions between the bed of the machine and the cutting tool, namely the longitudinal motion of the carriage and the transverse motion of the toolpost on the saddle.

(2) While the angle up which the tracer can climb is increased by 45 or 30 deg., rotation of the saddle reduces the angle down which it can descend by an equal amount.

(3) A lathe with an inclined slide is no longer a standard lathe and cannot readily be operated by an average machinist without some practice.

(4) In many applications it is convenient to machine part of a component by copying and the remainder by normal machining methods. For example, recesses and narrow undercuts are more easily and accurately produced by normal machining. This may be impossible on a machine with an inclined slide.

(5) Rear tools are most useful on many average components, but generally they cannot be used with an inclined slide. Where they can be fitted, they are often limited to transverse motion and therefore cannot be used as on a standard lathe. On the H.E.B. lathes rear tools can both slide and surface.

(6) The inclined slide generally reduces the swing over the carriage.

(7) It is difficult to design a really efficient swarf guard for use with an inclined saddle. This is an important point on a fast running machine from the point of view of operational safety. In addition, without a guard there may be a tendency to reduce the coolant flow to avoid splashing. This can be most destructive to the tool and perhaps also to the work.

(8) An inclined saddle may make it difficult effectively to prevent the leakage of coolant between the sliding surfaces and into the mechanism.

On the H.E.B. copying lathes the sliding motion is the same as that on an ordinary centre lathe. Shoulders are turned by means of the solenoid-operated slipping clutch described above. The saddle guides are of great length and provision is made for adjustment and taking up wear on the guides by means of tapered wedges at each end. The cross slide can be adjusted in a similar manner. Because of the sloping bed, the saddle is a very deep section and consequently is extremely rigid.

There are four transverse stops to permit the tool post to be fed in to previously adjusted positions. These stops are mounted on a rotating bar on the saddle. Their chief use on a copying lathe is for positioning rear tools for undercuts and similar work. They can also be used for setting the front tool when it is necessary to take roughing cuts. The tool slide may be brought up to the stops either by hand or by using the hydraulic system.

In addition to these stops there is a patented "Z" stop at the front of the tool slide. This is a micromatic stop with very fine adjustment. It consists of a hardened bar of rectangular cross section about 6in. long, pivoting about a steel ball that is a little off centre. The apron has a hardened projection which contacts the rectangular bar at its centre. Approximate positioning of the stop is by the differential action of two screws situated one at each end of the bar. Fine adjustment is obtained by tightening only one screw to cause a very slight deflection of the bar.

The "Z" stop is used in conjunction with the rear tool and the hydraulic cross feed. On account of the constant pressure at which this operates the tool is returned to the same position with a very high degree of accuracy. It can be relied upon to turn parallel diameters within a tolerance of plus or minus 0.0002in. As a single point tool, working in conjunction with the copying attachment, will turn chamfers, radii and other forms, it is not often necessary to use more than one front tool. On some applications more than one front tool must be used, and there is an H.E.B. four-way tool post of patented design for use with these machines. It can also be used to accommodate drills and boring bars.

To reduce vibration and ensure maximum life for carbide tipped a special front tool holder has been designed. It allows the tool to be clamped in a vertical position instead of the conventional horizontal position. The vertical position eliminates any overhang, and even a small overhang will produce a bending stress in the shank and consequent deflection. With a vertical tool both the tip and the shank are subjected to a purely compressive load. As a result, vibration is eliminated as is also any tendency for the tip to come away from the shank.

Furthermore, the wear on the tip of a horizontal tool is in the direction of minimum thickness and the number of possible regrinds is less than with a vertical tool. It is claimed that by placing the tool vertically its life is increased at least four times.

This type of holder considerably simplifies tool setting. Normally, adjustment of a tool to the correct height requires a great deal of care. With this holder the tool is merely raised in its clamping ring until its cutting edge is flush with the ground top of the tool holder block. The usual shims and wedges are completely eliminated. Inserting and setting a vertical tool on the H.E.B. lathe can easily be carried out in a few seconds. For light turning work, tool holders that will take standard horizontal tools are available.

The Apron

The apron is a casting rigidly fixed to the saddle and forming with it an oil-tight box. It houses the necessary gears and clutches to transmit the motion of the feed shaft to either the longitudinal or the cross feed. Change from one to the other is made by a swinging lever which also has an intermediate neutral position. Provision is made to prevent inadvertent engagement of one feed when the other is being disengaged. Longitudinal motion of the tool may also be obtained by means of a handwheel fitted with a large indexing ring and transverse motion by a handle similarly fitted.

Normally an air-operated tailstock is supplied with the machine in order to reduce loading times, but mechanically-operated and drilling tailstocks are also available. The standard tailstock is of very robust design and has a live centre mounted on taper roller and ball thrust bearings at the front and a ball bearing at the rear. If necessary, the 60 deg. male centre can be replaced by another centre without any disturbance of the bearing assembly. Where the utmost precision is required, an alternative arrangement is available in which the centre is carried in taper roller bearings front and rear, with the rear bearing pre-loaded by a series of springs.

The Copying System

The copying device is an integral part of the design. It combines the robustness required of a high production lathe with the great sensitivity necessary for very accurate duplication of dimensions. It comprises the following four essential elements :—

(1) The template carrier.
(2) The tracer and detection unit.
(3) The hydraulic system which transmits transverse motion of the tracer to the cutting tool.
(4) The electrical system for regulating the longitudinal motion of the cutting tool.

The template carrier is mounted on two rigid brackets, one at each end of the bed. These brackets support the table to which flat templates are clamped and the sliding centres for turned patterns. The design is such that it is not necessary to remove the table when the centres are being used or vice-versa. As a result a change from a flat template to a turned pattern can be effected in one or two minutes. In addition, as it is unnecessary to remove the centres, it is rarely necessary that they need adjustment for parallelism. However, a micrometer screw is provided at the tailstock end for adjustment. It is used mainly on initial assembly.

Contact between the tracer point and the template is maintained by a helical spring under pressure. The tracer arm is free to swing about two axes, one horizontal and the other vertical. Movement about the horizontal axis alters the valve opening in the hydraulic system and causes the tool slide to move across the saddle. Movement of the tracer arm about the vertical axis is detected by a micro-switch that controls the feed shaft motion. The tracer point is easily removable. It has a hard carbide insert to minimise wear.

Transverse movement of the tool post is effected by a patented live hydraulic system, because H.E.B. consider that at the present stage of development a well-designed hydraulic system is the best and simplest method of moving the tool post transversely at any required speed and for varying the speed as quickly or gradually as needed. It is interesting to note that they have designed and built an electronically-operated copying lathe for experimental purposes but they are firmly convinced that at present the hydraulic system is superior.

For this system, a $\frac{1}{2}$ h.p. electric motor drives a small pump that supplies oil at a pressure in the order of 2000 p.s.i. to both sides of the piston. On one side the pressure is reduced by allowing oil to escape by way of the valve in the tracer unit. As the two sides of the piston differ in area, the piston is in equilibrium when the pressures on the opposite sides are in the order of 2000 p.s.i. and 1000 p.s.i. Thus in the equilibrium position there is a considerable valve opening and any slight alteration in this opening caused by tracer arm deflection instantaneously produces piston movement. This "live" hydraulic system has far greater sensitivity than systems in which the equilibrium position is obtained by closing a valve and shutting off the oil flow. Such valves always have a certain amount of overlap which, no matter how small, causes a lag in the response of the piston to motion of the tracer, with the result that there are "deap points".

The cross feed screw is connected to the piston through two ball thrust bearings which are pre-loaded by means of a Belleville spring to ensure complete absence of any play. In addition, the nut that transmits the motion from the feed screw to the tool slide is provided with a backlash compensation nut. When the copying device is not required, the piston is brought right home and clamped by means of a ball lever.

An interesting and very useful element of the hydraulic system is the H.E.B. patent remote control. This is operated by a ball end lever above the tool slide. It allows the operator to open or close the valve in the tracer unit and move the tool slide hydraulically independently of the template. For example, at the end of a cut the operator can lower the ball lever to withdraw the tool from the work. The speed at which it travels is controlled by means of a knurled nut, a very simple and useful adjustment. This control is of great value when the rear tool is used for facing or undercutting.

Reference has already been made to the manner in which square shoulders are automatically copied by disengagement of the feed drive while the tool is withdrawn towards the front of the machine. This function is effected by means of the micro-switch that detects movements of the tracer arm about the vertical axis. Normally the micro-switch allows current to energise the solenoid at the end of the feed shaft, but when it is actuated as a result of the tracers' contacting a shoulder, the micro-switch de-energises this solenoid and instead energises a second solenoid in the tracer unit. This second solenoid closes the hydraulic valve and causes the tracer and the tool to withdraw until the tracer clears the shoulder.

It may be pointed out here that although the very slight lag in the operation of switches makes it inadvisable to use them in highly sensitive copying devices for the control of transverse motion, they are perfectly satisfactory for controlling longitudinal motion. For example, the tolerance of plus or minus 0.0015in. which the H.E.B. copying lathe will maintain on axial lengths at feed rates up to 16in. per minute is within the limits normally required. If greater accuracy is required, it can be obtained by reducing the feed. If however a similar electrical system were used to control transverse motion, diameters could only be guaranteed to within

plus or minus 0.003in., compared with the ability to maintain diameters to within plus or minus 0.0004in. that is afforded by the H.E.B. hydraulic system.

The degree to which the valve is closed by the action of the solenoid in the tracer unit is easily adjustable and very fine control may be maintained over the speed at which the tool slide moves. This is a very useful feature of the system. It makes the cross feed completely independent of the speed of the longitudinal feed. This is a major advantage in machining shoulders that require a very fine finish. Furthermore, this setting is independent of the speed obtained when surfacing is carried out by operation of the main control or when the mechanical cross feed is used.

A gear pump housed in the gearbox supplies the main lubrication. It delivers oil from a sump to three outlets. The first leads oil along an axial drilling in the gear input shaft whence it is carried to the plates of the friction clutches. Oil from the second outlet passes along a pipe to the top of the gearbox and from there it is sprayed on the gears. The third outlet is along a pipe to the top of the headstock. This supply is split up and distributed as a spray adequately to lubricate the headstock components. In addition to filters in the sump, there are special fine-mesh filters to prevent any possibility that particles of foreign matter will penetrate to the spindle bearings. A proportion of the headstock lubricant is led off to the feed gearbox where it is distributed to the necessary points. Independent methods of lubrication are provided for the apron, the transverse feed screw and the tailstock.

The machine is supplied complete with all internal wiring for the electrical system. In addition to the main motor, there are two small motors. One, of 1/10th h.p. drives the suds pump. The second, ½ h.p., drives the pump for the copying device. It is a special type of motor specifically developed for this duty. The main motor is started by means of a star-delta starter, which also controls the supply to various other electrical items. In order to improve the power factor when the motor is used at less than its maximum power, the star-delta starter is arranged so that the motor can be run in the appropriate one of three connections. These are star connection, intermediate connection and delta connection. If a machine fitted with a 20 h.p. motor is taking only a light cut requiring less than 6 h.p., the power factor is materially improved by leaving the starter in the first position. When the power required is between 6 and 12 h.p. the starter may be left in the intermediate position. The power required for any particular cut is indicated by an ammeter fitted in the headstock.

A good range of ancillary equipment is supplied with the machine, and many extra items that have been specially designed for use with the machine can be supplied as extras. In addition, H.E.B. design and manufacture special attachments for machining specific components that are required in large quantities. For example, to cut machining times and costs in the manufacture of light alloy pistons, H.E.B. have produced modified copying lathes with a special bracket built on to the headstock to allow the grooves to be machined at the same time as the piston is turned. This bracket has a tool slide feeding vertically and carrying the necessary tools for cutting the grooves. An OP hydraulic copying lathe and other H.E.B. lathes are now on demonstration at the showrooms of Selson Machine Tool Co., Cunard Works, Chase Road, London, N.W.10. H.E.B. Machine Tools Ltd., 79, Portland Place, London, W.1., are the sole distributors to the British Empire for these and other machine tools built by H. Ernault-Batignolles.

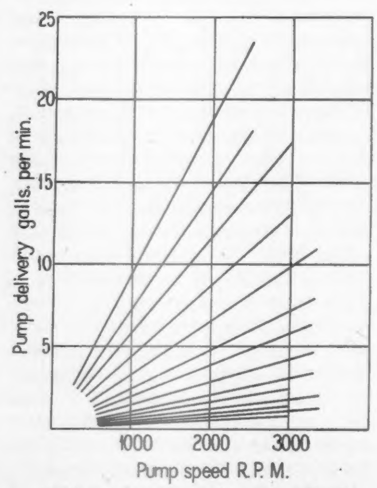
HYDRAULIC PUMPS

A Modified Series for Industrial Application

WITH a view to meeting the increasing demand for hydraulic power to operate auxiliary attachments and controls in a wide variety of applications, the Plessey Company, who have long been making hydraulic plant for aeronautical use, has just introduced a rationalized range of hydraulic pumps for industrial use.

Ingenuity and care in design has make it possible to produce fourteen separate capacity pumps in only three different basic sizes. This result is attained by using different sizes of gears and bearings in one housing, thus using the largest possible number of common parts in each group. In the two smaller sizes, five variations are used. In the largest size there are four.

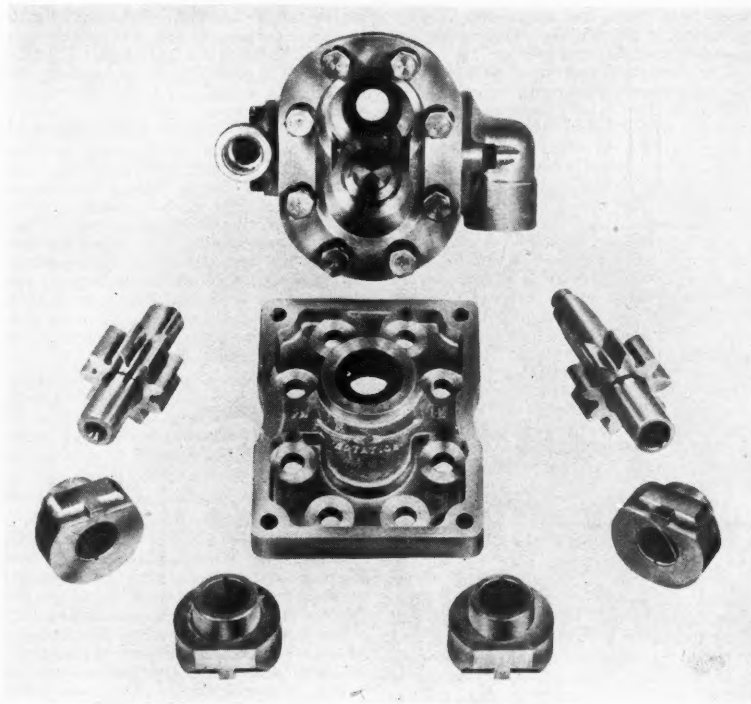
All the pumps are of the straight gear type. Capacity in each group is determined solely by the effective width of the gears. The body of the pump is in two parts, casing and cover. Both are die cast in D.T.D. 424 aluminium alloy, heat treated after casting. The covers are secured to the casings by set screws in the two smaller sizes, and by set bolts in the largest. The gears and shafts are integral, being machined from 3 per cent nickel, case hardening steel. Gear teeth are hobbed and shaved. The bearings are 20 per cent lead bronze, indium plated. Synthetic rubber tube is used for oil seals.



Performance curves for rationalized pump range.

With this type of pump, efficiency depends on the maintenance of very close tolerance between the gears and the mating parts. Radially, this is secured by setting the tolerance at from a slight clearance up to 0.0025in. interference. In that stage the gears mould the casing to a practically negative clearance, thus providing the best condition for high efficiency. To avoid pressure losses between the sides of the gears and the bearings, the pumps are designed so that the bearing on the cover side is free to float sideways.

Oil is ducted to the outer side of the bearing so that it is pressed up against the gear, and that again, in turn, against the inner bearing. Any tendency towards a tilting action of the gear is prevented by the introduction of a separate low-pressure area at the inlet side to correspond with the low pressure of entry, while the remainder is under the same higher pressure as the outlet area.



Component parts of Plessey pump.

The drive is normally taken at the front of the pump, but it can be taken from the back by the simple expedient of turning the drive shaft end for end. All that is then required is a different type of name plate cover at the back of the casing. With the drive taken at the front, it is possible to use an extension shaft so that the pump can be fitted in tandem, or for the addition of a starting handle dog should the pump be fitted to the front of an internal combustion engine. Reversibility of rotation is effected by changing the relative position of driving and driven gears and by turning the cover plate through 180 degrees. The cover plate also acts as a mounting flange and has a clearance hole at each corner.

The inlet and outlet ports are arranged diametrically opposite on either wall of the casing, adjacent to the cover plate. The flange to each port is identical, being square in form, and having four drilled attachment holes. Two adaptors only are necessary, one straight, the other right-angled. As an angle adaptor can be fitted in four positions on either side, it means that the two types of adaptor give twenty-five possible alternative arrangements of inlet and outlet to any one pump.

The makers claim that this range will pump at an overall efficiency of not less than 80 per cent. In fact it is claimed that under the best operating conditions the volumetric efficiency ranges from 92-99 per cent. The capacities and performance of the pumps is best appreciated from the accompanying curves.

At a recent demonstration of these pumps several were shown on test pumping a wide variety of fluids with almost equal facility. A model 3H43 was being subjected to acute shock loading, the operating pressure being changed from 500 lb sq in to 2,000 lb sq in at three second cycles. The pumps are not suitable for common fluid.

RECENT PUBLICATIONS

Brief Reviews of Current Technical Books

Body Engineering

By Sydney F. Page, M.I.B.C.A.M., M.M.I.A., A.M.I.E.D.

London: CHAPMAN & HALL, LTD., 37, Essex Street, London, W.C.2. 1950. 5¾ × 8¾. 188 pp. Price 24s.

The scarcity of instructive literature covering the many activities which combine to form the practice of coachbuilding has long been recognized and those concerned with the training of future craftsmen have endeavoured to repair the omission by making available books published abroad principally in America. It is therefore encouraging to find that a qualified member of the industry in this country has produced a book that constitutes a comprehensive survey of prevailing methods. The building of coachwork, whether it be for private, commercial or heavy passenger carrying vehicles, involves the use of many widely differing materials, and in a book of this length it is obviously impossible to do more than give a general description of these. The book is divided into eight sections, the introductory chapter beginning with a survey of the development of the motor car from 1896 to 1946, and indicates the several factors that led to fundamental changes in design. The second section is devoted to a general review of the materials used in the construction of body work, and in the ten pages allocated to this important subject, half is occupied by a description of the timbers commonly used.

Particularly valuable are the two sections that follow, and deal with design problems and drafting procedure. Useful guidance is given in the preparation of paper for the full-size layout. Mention is made of the use of thin aluminium sheets as an alternative to linen-backed paper but the author makes no reference to the horizontal layout tables which most production drawing offices now seem to prefer to the vertical drawing board. It is interesting to note that the method involving the use of 10in. squares for layout drawings is recommended, but whether the front axle centre line, or the dash is the best vertical datum is debatable. The author favours the front wheel centre line, but since practically all coachbuilders' chassis drawings use the dash as a datum line for all longitudinal dimensions it would seem that the zero vertical line should correspond. A table of standard body sweeps is given, also the method to be used for developing a ramshorn curve.

Sheet metal projection is an interesting subject and in the chapter devoted to it the general principles of proportional development are dealt with. Further sections deal with caravan trailers, body fittings and practical construction. This book should prove of great value to students for, while it may not provide the complete answer to a problem, it will at least give an idea of the procedure to be followed.

Automobile Electrical Equipment

By A. P. Young, O.B.E., M.I.E.E., M.I.Mech.E., and L. Griffiths, M.I.Mech.E., A.M.I.E.E.

London: Published for *Automobile Engineer* by ILIFFE AND SONS LTD., Dorset House, Stamford Street, S.E.1. 1950. 386 pp. 5½ × 8½. Price 25s.

The principles of automobile electrical equipment have not changed since the first edition of this book appeared in 1933, but practical applications and advancements have necessitated expansion of text matter several times so that this, the fourth edition, embodies much that is new. Notes are now included dealing with radio interference suppressors, modern sealed-

beam headlamps, and fluorescent lighting in connection with the illumination of passenger transport vehicles.

The theoretical and practical aspects of the subjects are dealt with side by side. The method adopted by the authors is to treat the theory first, in each case, and follow immediately with practical applications. This scheme is followed throughout from sparking plugs to batteries and magnetos. The theory employs the minimum of mathematics.

The fundamental principles of electricity and magnetism are given first and followed by separate chapters dealing respectively with the dynamo, starting motor, battery, lighting, and ignition. Ignition is divided into nine sections under sub-headings covering ignition systems, battery-coil ignition, magnetos, sparking plugs, etc. Thus, nearly half the book is devoted to this most important part of automobile electrical equipment. Considerable space is also devoted to magnetos, and almost every make is sectionally illustrated and described.

The illustrations are valuable, since they cover not only equipment now in production, but also, in many cases, that still in use but not now fitted. To the service electrician, this is most useful. The section on aeroplane magnetos has been deleted from this edition, it being the intention of the authors to enlarge this and to produce it eventually as a separate book.

In short, the book provides a complete survey of lighting, starting and ignition equipment for motor cycles, motor cars, and transport vehicles new and old, and it is profusely illustrated with line drawings and half-tone reproductions.

Eighty Years of Enterprise

By R. Stanley Lewis, M.I.Mech.E.

Ipswich: W. S. COWELL, LTD., Butter Market, Ipswich. 1950. $7\frac{1}{4}\times 9\frac{3}{4}$. 112 pp. Price 10s. 6d.

This is the history of the Waterside Works of Ransomes & Rapier, Ltd., Ipswich, written by one of their directors who was their chief engineer from 1930 to 1940, and who has been fifty years with the company. This company has a history that is well worth reading about, and it is written in a style that appeals to anyone interested in the intimate story of an industrial undertaking that has risen from very small beginnings to world renown in only fifty years.

Readers will note the originality and ideas that the directors and executives have always evidenced. The fact that these ideas have been practical ones has done much to assure the success of the company. For example, they built the first railway in China in 1872, they were responsible for the Stoney sluice gates when Mr. Stoney was their works manager, they made the revolving stage for the London Coliseum in 1904, the Stokes gun of the 1914-1918 war was designed by their managing director, Sir Wilfred Stokes, they constructed the largest breakdown crane ever made on metre gauge, they have been connected with all types of cranes, catapults for launching aircraft, and more lately with excavators.

No one will fail to be impressed with the story of the engine made for the first Chinese railway that ran out there for a year and then ran until 1929 on the Southwold railway in Suffolk. Similarly, the brief description of the largest walking dragline in the world provides impressive proof that the company is still advancing with the times. This machine is the length of a football pitch and has a working radius of 260 feet, employing sixteen 225 h.p. electric motors, the power for which is generated in an engine room as large as a full-size tennis court, and weighs 1,600 tons.

These achievements could not have taken place unless the company had the backing of their employees, and the book instances many happy facts about this relationship. The author remarks in the last chapter, that the modern engineer has called Nature's bluff. It would seem as if this has been the chief endeavour of this company throughout its history, and the story of how this has been done is described in this book in a manner consistent with the prestige that Ransomes & Rapier, Ltd., enjoy to-day.

Helical Springs

By J. R. Finniecome, M.Eng., M.I.C.E., M.I.Mech.E., F.Inst.F.

Manchester: EMMOTT & Co., LTD., 31, King Street West. 1949. 60 pp. $5\times 7\frac{1}{4}$. Price 2s. 6d.

This book is No. 56 in the series "Mechanical World Monographs" and deals with a subject that is eminently suitable for treatment in a booklet of this type. The design of helical springs for modern machines requires a knowledge of the results of considerable critical study and analysis. The fundamental torsion theory does not explain fractures caused by excessive strains, and designers have had to study many intricate stress problems. The author pays particular attention to many authoritative investigations on closely coiled, circular-sectioned springs, and presents the results by formulae, graphs, and charts. He deals with the theories of Röver, Wahl, Honegger, and Göhner, and compares the stress factors of these five workers.

Some interesting sections discuss frequency of vibration, surge wave velocity, surging stress, torsional elastic limit, etc. Interested readers will find a comprehensive survey of present-day knowledge of the theory and practice of helical springs of circular cross section and the book shows that the stress factors relative to the simple torsion theory for the five principal authors quoted agree very closely.

High Speed Computing Devices.

By the Staff of Engineering Research Associates, Inc.

New York: McGRAW-HILL BOOK Co. INC. Available from McGRAW-HILL PUBLISHING Co. LTD., Aldwych House, London, W.C.2. 451 pp. $5\frac{3}{4}\times 9$. Price 55s. 6d.

Industry to-day is research minded and in evolving new theories that will eventually assist in production, the key word is speed. Advancements must be made ahead of other nations, or at any rate ahead of competitors at home and overseas.

A research body must be an intelligently organized body, with all its members working together as a team. Many of the team need not be scientists. Some may be mathematicians or statisticians, with little knowledge of the ultimate goal to which they are working, and some may be merely machine operators. The machines are indispensible to any scientific department; they, and they alone enable inventions to be put into practice in time.

It is with these machines that this volume is concerned. The simplest type of computing machine is probably the small adding machine, used in every large office, and now in common use. But high speed computing devices of extraordinarily complicated character are employed to carry out all the calculations necessary to enable scientists and statisticians in every type of industry to complete their preparatory investigations without loss of valuable time.

This book is not a description of available computing machines, but rather a discussion on the mechanical devices and electrical circuits that can and may be incorporated into these machines. Of the machines individually referred to, only American ones are included, but the very numerous references provided throughout the book clearly show that the information given is international.

Large-scale computing machines have been developed particularly for Government work, and for the Services, and this book was first prepared in the form of a report for the Office of Naval Research in the U.S.A.

Those engaged in designing or using these complicated machines will obtain valuable information regarding the types of machines that can be constructed and the type of computing system that is most applicable to their specific problems. Many too, will desire to know more about the systems of computation themselves, whilst mathematicians and statisticians will be interested in the book because it will ensure that they keep ahead of modern developments in this important, and complicated type of machine.

Factory Canteens, Their Planning and Equipment

By H. M. Harman.

"MECHANICAL WORLD MONOGRAPH", published by EMMOTT & Co., LTD., 31, King Street West, Manchester, 3. 1949. 45 pp. Price 2s. 6d.

Nowadays the majority of workers never leave the works premises at all during the day, and the greater part of their relaxation time is spent in the works canteen. The important psychological effect of bright and cheery canteens is stressed in this booklet, since the greater the contrast between workshops and eating places, the greater the break for the workers. The author suggests that it is very convenient for the canteen to be combined with a concert and dance hall, and keeps this in mind throughout the book whatever aspect of the planning he is dealing with

All stages of canteen planning are dealt with, from the initial layout to the final details of kitchens, food preparing rooms, service, and the several dining rooms for workers, staff and directors and executives. Helpful suggestions are made about equipment, furnishing and the arranging of the contents of the various rooms, and perhaps the most useful thing in the whole book is the space devoted to the problem of overcoming the long queues which are so often the bugbear of communal meals.

The book outlines all the aspects to be considered in the planning of canteens, and gives a good idea of the amount of equipment to be required. It also deals helpfully with the question of the size according to the number of workers likely to use the canteen. It does not, however, give any help as to the probable cost of the work of building and then running a canteen, nor the number of staff needed to run it. Nevertheless, the suggestions in it are useful and the subject is dealt with quite thoroughly, if briefly, so that it would serve as a valuable guide to anyone considering building, or rebuilding, canteen premises.

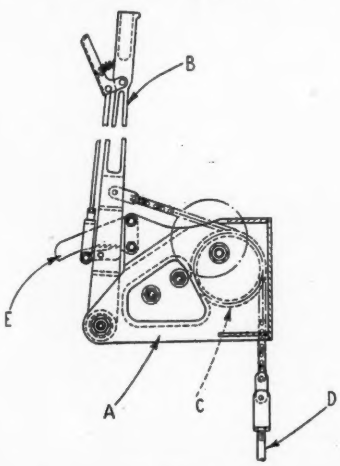
CURRENT PATENTS

A Comprehensive Review of Recent Automobile Specifications

Hand Brake Lever

AFTER a rapid take-up of any slack in the linkage and clearance at the brakes, continued movement of this lever is effected with an increased leverage ratio to apply greater pressure on the brake shoes. The mechanism is mounted between two spaced plates A, one of which is bracketed for attachment to the vehicle frame. Hand lever B and an eccentric sprocket C are each mounted on spindles secured within the plates and a roller chain from the hand lever passes round approximately 90 deg. of the sprocket and is connected to the brake rod D.

As the hand brake is moved, the eccentric sprocket is turned about its spindle thus altering the rate of movement of the brake rod relative to that of the lever. The eccentric sprocket is so arranged that there is a maximum rate of rod movement to take up the brakes and thereafter the rate of rod movement gradually decreases. A



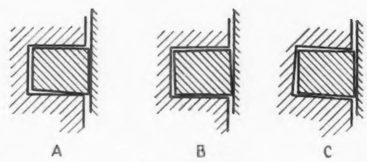
No. 631649

trigger-operated pawl engaging a quadrant ratchet E is provided to hold the lever in an engaged position. *Patent No.* 631649. *Fodens Ltd., W. Foden and E. Twemlow.*

Compensating Piston Ring

IN conventional practice, ring grooves are machined with their radial walls truly at right angles to the piston axis and when working temperatures are reached these walls will become slightly "downswept" or convex towards the crown. As a result the ring tends to tilt or dish slightly and thus the upper peripheral edge will engage the cylinder bore with a greater pressure than will the lower edge.

As a corrective measure it is proposed to machine the ring with its lower radial face at an angle less than 90 deg. to the axis. For clarity, the angles and clearances are exaggerated in the diagrams. At A the frusto-conoidal ring is shown stationary in the cold condition. When working at piston temperatures below that of normal operation, the gas pressure above the ring will tend to dish it concave towards the crown as at B. As soon as normal



No. 626406

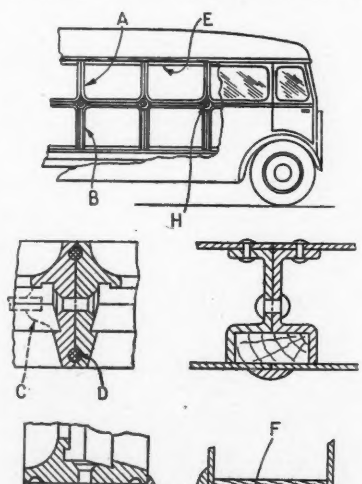
operating temperature is reached and the groove becomes "downswept", as at C, the ring will be tilted to bring the peripheral surface substantially parallel to the cylinder bore. *Patent No.* 626406. *Wellworthy Piston Rings Ltd. and J. W. Howlett.*

Bus Body Framing

INSTEAD of the usual pillar construction this bus body is built up of a plurality of rectangular, substantially rectangular or U-shaped glazing and panel frames secured together somewhat in the manner of a sectional tank. For a single decker bus, each side of the body comprises a series of U-shaped glazing frames A and a similar number of inverted U-shaped panel frames B disposed immediately below. The adjacent sides of these frames are secured together by screws, bolts or rivets to constitute, in effect, vertical pillars.

Each glazing frame may be of an aluminium alloy formed to a suitable cross-sectional shape to accommodate a resilient glazing strip C and sealing cords D to exclude water. The upper ends of two sides of each glazing frame are joined by a horizontal top rail E attached to seating blocks F, shaped to fit into the glazing channel and secured by screws.

Panel frames are of a different cross sectional shape with an L-shaped flange on the outer side to receive a wooden tacking strip G to which the exterior panels are secured. The inner panels are riveted to



No. 627198

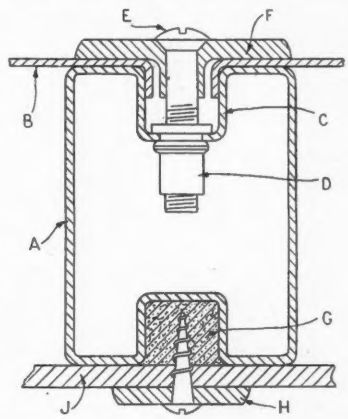
the other flange. Adjacent sides of each pair of frames are riveted together and the two L-shaped flanges form a channel to receive a common tacking strip.

All frames are formed with radiused corners and in the space remaining at the junctions is fitted a flanged block H tapped with four holes to receive screws passing through the corners of the frames.

Claimed to produce a strong and rigid structure this construction avoids the use of welding which might impair the inherent strength of the frames and enables the body to be conveniently packed for transit or storage and readily assembled at its destination. *Patent No.* 627198. *A. S. Cheston, E. C. Edmonds, B. Cheston and F. A. M. Oldham.*

Panelling Bus Bodies

THE practice of securing metal panels by means of a moulding strip which wedges inwardly turned flanges on the panels into a groove in a framing member is liable to be



No. 631700

not completely satisfactory should there be local variation in metal thickness, groove width or wedge width. In any of these contingencies the strip may bear unevenly on the panels, some portions standing proud of the panels and possibly leaving weather-leakage spaces. The method proposed enables unstressed metal panels to be assembled on a frame member in a rattle-proof and adequately weather-sealed manner without close dimensional limits.

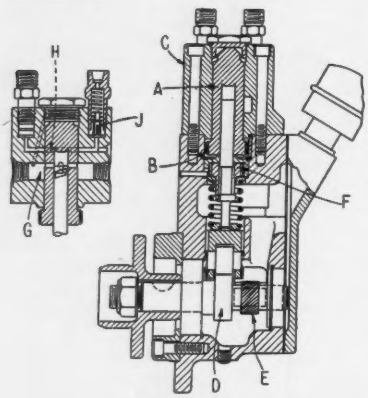
In the example, an H-section tubular frame member A is fitted with metal exterior panels and wooden or plastic interior panels. The flanges of metal panels B are hooked over the shoulders of framing A into the centrally arranged groove C. In the bottom wall of this groove are secured captive nuts D to receive screws E by which the moulding strip F clamps the panels firmly against the shoulders of the framing.

For the interior of the structure, a groove in the framing houses a wooden or fibre fillet G, secured by any convenient means, which serves as an anchorage for wood screws holding moulding strip H to clamp panels J. *Patent No.* 631700. *Strachans Successors Ltd., and E. T. A. Houldcroft.*

Rotating Cylinder Injection Pump

A SINGLE plunger making four reciprocations during one revolution of the pump cylinder supplies injection fuel for a four cylinder engine. The pump cylinder A, with a spur gear B, formed integrally at the lower end, is rotatable in a bore in the body C secured by four cap screws to the main casing. Driven at half engine speed, the shaft has a four-lobed cam D to reciprocate the pump plunger and a spiral gear E. From this shaft the pump cylinder is rotated at equal speed by means of a vertical shaft with complementary spiral and spur gears at its lower and upper ends.

The pump plunger is normally held against rotation but is angularly adjustable by means of a rack F and pinion to vary the delivery of the pump in the usual manner. Fuel is supplied to a charging zone G and the outlet port H in the cylinder registers in turn with the four delivery passages in the body from which pipe connection are taken to the injectors in the engine cylinders. Each delivery passage is furnished with a non-return check valve J. *Patent No.* 631005. *International Harvester Company of Great Britain Ltd.*



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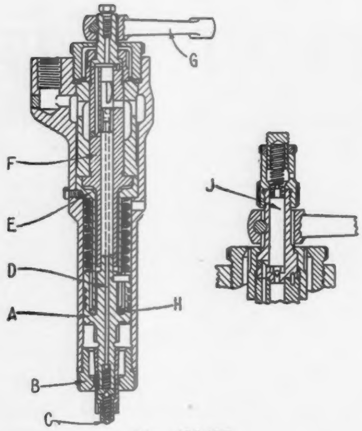
Gas Operated Pump-Injector

THIS combined fuel pump and injection nozzle is operated by the compression pressure in the engine cylinder acting upon a gas piston. The pumping component is located in the upper portion of the body and is cooled by the incoming fuel. Gas piston A reciprocates in a chamber constituted by a bore in the lower end of the body and an apertured cover B. The tapered extension of the piston projects through the cover orifice and carries at its outer end an injection nozzle C. On the opposite side of the piston an axial extension forms the plunger of the fuel pump and a drilling D permits the transfer of fuel from the pump to the nozzle. Possible rotation of piston and plunger during operation is prevented by a guide pin engaged in a slot in the end of the abutment member E upon which the loading spring is seated.

Control of the quantity of fuel injected is on familiar lines by means of a helix on the plunger but in this instance the variation is effected by turning the pump cylinder F about the plunger by means of lever G.

A careful selection of dimensional proportions is necessary to ensure the most efficient operation. It is suggested that when the gas piston is fully returned the effective area of the annular orifice between the cover and the nozzle should be between 0.5 per cent. and 2.0 per cent. of the cross



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sectional area of the piston. Forming the nozzle extension to a taper of between 1 in 16 and 1 in 4 on the diameter will ensure a sharp pressure rise in the gas chamber during the injection period and also exercise a dashpot effect to cushion the piston on its return stroke.

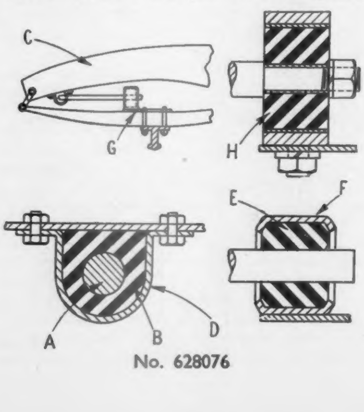
The volume of the gas chamber when the piston has completed the return stroke has a controlling effect on gas temperature, rate of lift and cushioning effect and is selected within the range of from 5 per cent. to 60 per cent. of the volume swept by the gas piston. In any case the specified minimum volume should not exceed 5 per cent. of the engine combustion space.

The porting arrangement of the fuel pump is such that after the fuel under pressure has been relieved to terminate injection, some fuel is trapped within the cylinder and provides a hydraulic cushion at the end of the injection stroke. As a standby in the event of the cylinder being empty a resilient ring H is provided in the pump piston to prevent damage.

In a modification an auxiliary device for varying the point when injection commences is included. This comprises an adjustably loaded needle valve J controlling the delivery port from the fuel pump cylinder. *Patent No.* 630437. *A. J. Morris and R. A. Lister & Co., Ltd.*

Mounting Anti-Roll Bar

BY making all connections of this torsion bar anti-roll stabilizer to the sprung and unsprung assemblies through the medium of rubber blocks, any divergence in the respective paths of travel is accommodated, no lubrication is required and there is no tendency to develop noise. With the conventional layout of semi-elliptical springs the torsion bar A is carried in rubber blocks B clamped to the flanges of



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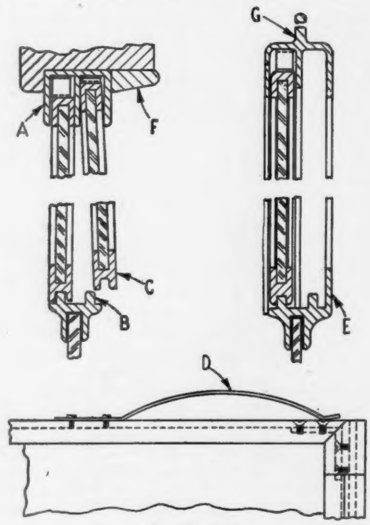
frame side members C by straps D.

At their free ends the arms of the bar are inserted in rubber blocks E carried in a metal retainer F, welded to brackets G and clamped to the springs by the usual U-bolts. In both cases, the rubber blocks may be either stressed over the torsion bar sufficiently to prevent slipage or may be vulcanized to the bar.

As an alternative, the mounting for the free ends of the arms may be a cylindrical block of rubber H vulcanized to internal and external metal sleeves to form a unitary construction. In this instance the end of the roll bar arm is reduced in diameter and the bushing is secured by a nut. *Patent No.* 628076. *Monroe Auto Equipment Co. (U.S.A.).*

Slidable Ventilation Windows

WINDOWS or half windows are slidable horizontally in an outer frame having deep channel guides A for the upper run and vertical ribs B for the lower run. The lower edge C of the individual window



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frame is channelled to engage the rib and thus will not collect either water or dirt and is virtually self-cleaning. The channels in the upper run of the frame are sufficiently deep to accommodate within them a leaf spring D, or a spring-urged bar secured to the upper edge of the window frame. The spring maintains the lower edge of the window in firm association with the rib of the outer frame whilst permitting sliding movement in either direction and providing sufficient friction to hold the window in its adjusted position.

Commonly, only one of a pair of these windows will be required to slide whilst the other, of similar construction, is held stationary by means of a simple stop device. Both can be readily removed by raising against the spring until the bottom edge clears the rib and then swinging bodily and withdrawing from the upper channel.

In a modification, an additional precaution against the ingress of water is furnished by a flange E along the lower run of the framing. When this is used both windows must be removed outwardly. The outer framing may be fixed in the vehicle body structure by seating against a rebate and securing by a strip F. Alternatively, the framing may be formed with a peripheral rib G and mounted in channelled resistant glazing strips. *Patent No.* 627986. *W. Bramham and Eastern Coach Works Ltd.*